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NEW YORK, SEPTEMBER, 1893.

EDITORIAL NOTES.

A CURIOUS objection to the use of the telephone is said to exist in the mind of the Sultan. He will have none of it in any of the cities of his dominions, on the ground that his subjects are all too ready to intrigue and conspire against his happiness, and he does not propose to allow the introduction of any device whereby this conspiring can be made easier. It is stated that this prejudice is so deep-rooted that those interested in telephone development have ceased to make any efforts to secure franchises in the land of the Turk.

RAPID transit for New York still seems to have a lingering life. The latest development is that the Rapid Transit Commission has cut loose from the Manhattan Elevated Railway, and are making some sort of proposals to build independent elevated railways. This is said to have brought the Manhattan to a reconsideration of the terms proposed before, and there the matter is again resting. It would be hazardous to make any predictions looking toward a speedy settlement, and it is probable that the first of January will see the end of another year and nothing accomplished.

WE would call especial attention to the brief report that appears in another column of the Aerial Navigation Convention recently held in Chicago. Not that there are any novelties in the shape of facts set forth in the report, but because the position taken by those most interested in the matter is so clearly elucidated. It is not expected that express speeds will be attained, or that aerial navigation will soon reach a stage of development that will present an attractive field for commercial investments, but simply that aerial navigation promises to become an accomplished fact though it may not supplant the locomotive and the ocean steamer.

WE mentioned in our last issue that the Government was after something marvelous in the shape of a torpedo boat, and now we have to record that the Board appointed to report on the designs submitted consider that the one of them which most nearly meets the requirements should be built. Of the two that may be considered as competitors, the Holland is designed with a strength sufficient to resist a submergence of 70 ft. and the Baker for one of 150 ft. The recommendation, however, is that the former boat be built. No action has as yet been taken by the Department of Construction. Should the boat accomplish what is expected of it, there will be an element introduced into naval warfare that will go very far toward making the operation of a blockading fleet inoperative.

A CURIOUS case of objectionable interference between a railway and its employés is given by an English correspondent of the *Independent*. In order to avoid the responsibilities of the Employers' Liability Act of 1880, the Brighton Company instituted an insurance fund, which any of its employés were at liberty to join, but were not compelled to. But in so doing the applicant signed a contract freeing the employer from all liability under the act. The premiums were so low that the company was called upon to make up a large deficit, but the accident insurance was complete and covered every form of accident, whether it came within the provisions of the act or not. But the idea was an unpopular one among the labor organizations, or at least among the leaders of such organizations, and now there is a movement, despite the protests of the employés, to make such a form of contract illegal. In other words, the labor leaders propose that all men shall be saved in their own peculiar and particular way.

MONTHLY MEETINGS OF MECHANICAL ENGINEERS FOR TECHNICAL DISCUSSION.

FOR a year or more past various members of the American Society of Mechanical Engineers have expressed a desire that more frequent meetings of the members should be held, which should be devoted to the discussion of subjects pertaining to their various occupations. A sort of half-hearted and unorganized effort of this kind was made in the winter of 1891–92, and even under the unfavorable conditions which then prevailed a number of the meetings proved to be very entertaining, instructive and profitable, and indicated what might be accomplished if they were conducted by an intelligent committee who felt an interest in their success. For several years past what are called "reunions" have been held each month during the winter, which were attended by members, their wives, sisters, cousins and their aunts. Some one has disrespectfully designated these meetings as "*petticoteries*," but even with this title many members found them very agreeable, and doubtless there would be much regret—in which the writer would share—if they were discontinued. They were, and probably always will be, social in their character. There are quite a considerable number of members—just how many has not yet been ascertained—who feel that purely social enjoyment should not be the only aim in the meetings of a society like that of the Mechanical Engineers. While they are quite willing and ready to dress, and talk, and eat, and smile and flirt—if need be—at the petticoteries, they feel that meetings for the consideration of subjects for which the Society was organized, if held at least once a month, would be both pleasant and profitable.

To such a scheme the objection has been made that the Society is a national one, and that it would be impolitic to organize and hold a series of meetings in which a large proportion of the members could not participate on account of their distance from New York. It is a curious fact that those who urge this objection most strenuously are the most active at the Society's sociables, which have been held monthly. On the principle upon which objection is made to holding monthly meetings for technical discussion, non-resident members might object that we, who live in New York, are the recipients of an undue proportion of smiles and allurements which are so graciously disseminated at the meetings referred to.

It is also objected that the rules of the Society make no provision for monthly technical meetings, although it is specifically stated in Article 36 that "other regular meetings (besides the annual one) of the Society shall be held in each year at such time and place as the Council may appoint." Still, as there is some objection, on the ground of expediency, the members who have felt an interest in holding monthly meetings during the coming fall and winter, for the discussion of technical matters, have considered the advisability of making them not meetings of the Society, but of *members* of the Society. There is at present no reason why two or three, or two or three dozen members, may not meet in the rooms which the Society occupy and discuss any subject whatsoever. The plan that has been proposed is a very simple and direct one, which is to organize a committee which shall take charge and direction of the meetings. This will consist in selecting subjects for discussion, inviting competent persons to open and start it, appoint a chairman to preside, select the time and place for holding the meetings, issue notices and announcements of them, and exert themselves generally to promote their interest and profit.

The practice and past experience of a kindred society, which now meets in the Mechanical Engineers' hall, may be quoted as supplying a type of meetings which might be imitated. The society referred to is the Railroad Club. As originally constituted it had no constitution, rules, or membership. The only organization was a committee, which originally was self-appointed, and conducted the proceedings and filled vacancies which occurred. It now has a constitution and by-laws, membership and officers, and a regular organization. In its early years, however, the committee referred to took entire charge of everything. For each meeting a subject was selected by the committee which it was thought would interest railroad men. A person who was an expert on the subject selected was then invited to make a short address not exceeding 20 minutes or a half hour in length, in which interesting facts, theories or experiences were presented. This served to excite the interest of the audience, stimulate the thoughts of those present, and steer the discussion.

A formal paper is apt to be a bore to a large proportion of an audience. It often happens in the meetings of the Railroad Club that machines, tools, models, drawings, samples or other objects are presented and exhibited at the meetings which serve to excite interest. When this is once accomplished discussion always follows.

One result of holding these meetings at an appointed time each month is, that those who are interested in them and who live outside of New York arrange their business so as to be here on the date of the meeting, and thus these monthly occasions become reunions of people living in different parts of the country and who have like interests. The same results would be sure to follow similar assemblages of mechanical engineers.

Of course if such meetings should meet with favor, it might be desirable to hold them either under the auspices of the Society itself or to form some regular organization to take charge of them, but in the beginning this is not needed. Members of the Society who feel an interest in this scheme are solicited to signify their approval or disapproval by communicating with the editor of the AMERICAN ENGINEER.

CYLINDER PROPORTIONS.

THE following inquiry comes from a correspondent:

"Assume that a new locomotive is to be designed for a given service. Knowing the maximum grades, radii of sharpest curves, maximum weight of train and speed of same, the maximum train resistance is approximately determined. The boiler pressure, stroke and diameter of drivers are known.

"On page 595 of 'Meyer's Modern Locomotive Construction,' I find the following formula for finding the diameter of the cylinders

$$d = \sqrt{\frac{T \times D}{P \times S}};$$

where T = tractive force; D = diameter of drivers in inches; P = mean effective pressure; and S = stroke in inches.

"Now, the question which perplexes me is, What value should be given to P?

"If P is taken at .90 of the boiler pressure, as recommended on page 541 of 'Catechism of the Locomotive,' for slow speeds and late cut-offs, then at high speeds and short cut-offs the value of P will be so greatly diminished that the engine will be unable to perform the work for which it was designed. In other words, the cylinders will be too small for expansive working.

"On page 4 of the AMERICAN ENGINEER AND RAILROAD JOURNAL, January, 1893, I find a table showing approximately the mean effective pressure in per cent. of boiler pressure, due to speeds of from 6 to 75 miles per hour, with drivers of from 50 to 78 in. diameter.

"Could not the value of P in the above formula be calculated approximately from this table, and the diameter of cylinders determined accordingly?

"Having thus obtained the diameter of cylinders, the maximum tractive force at starting could be calculated with an assumed maximum effective pressure .90 boiler pressure. Then tractive force $\times$ 5 = adhesive weight.

"Would it be practicable to assume that the locomotive is to perform its maximum work with a given point of cut-off, release and compression; lay out the theoretical indicator diagram and calculate the mean effective pressure therefrom? The mean effective pressure thus obtained could only be approximately correct, as the clearance at this stage of the design would be unknown and the back pressure could only be assumed.

"Is there any arbitrary mean effective pressure used by builders in designing the cylinders of express, freight and switching locomotives?"

Our correspondent's difficulty seems to arise from a desire to make a locomotive which will exert its maximum tractive force while working steam expansively during a considerable proportion of the stroke. We will assume that in doing this that he wants to cut off steam at three-eighths of the stroke, and expand it during the remaining five-eighths. The average pressure of steam in the cylinders with this point of cut-off would be less than 70 per cent. of the boiler pressure. Consequently, in order to get cylinder capacity enough to turn the wheels, the cylinder must be made larger than would be necessary if steam was worked full stroke, or as near full stroke as an ordinary slide-valve will permit. If they are thus enlarged, then if steam is worked full stroke at any time, the cylinders would have too much capacity for the adhesion of the wheels, and they would then be liable to slip. In other words, if the cylinders of a locomotive are made large enough, so that it can exert its maximum trac-

tive effort when cutting off at a small fraction of the stroke, it will be liable to slip its wheels when working full stroke.

It is essential to work steam full stroke in starting, because when the valves are cutting off steam short, the engine may, and frequently would, stop in positions in which both valves would be closed, or rather the admission ports of both cylinders would be closed. It would then be impossible to start.

Still another difficulty at low speeds would be that in cutting off short, the rotative effect exerted on the wheels is so irregular that an engine could not exert its maximum power. The best that we can do, then, is to proportion the cylinders, so that when working full stroke the pistons can exert just enough tractive power so as to slip the wheels. After making all the deductions for loss of pressure in the cylinders, and it is found that all we can count on is 90 per cent. of the boiler pressure as effective pressure in the cylinders when steam is cut off as near full stroke as the ordinary slide-valves will permit.

If the cylinders were increased in size and we attempted to exert more power at high speeds, it would then be impossible to supply enough steam. It is found that when the cylinders are proportioned so that they can just slide the wheels in starting and when working full stroke, that there is then always cylinder capacity enough to use up all the steam that can be supplied at high speeds, even when cutting off short.

STANDARD RAIL SECTIONS.

Engineering News of August 17 publishes engravings of the forms of "rail sections recommended as standard by the Committee on Standard Rail Sections of the American Society of Civil Engineers." These were presented with a report at the business session of the late Engineering Congress at Chicago. The same paper also publishes an editorial on the subject of the report, in which the editor congratulates all the world on the fact that this committee has recommended that the radius of the upper corners of the rail-heads shall be $\frac{5}{16}$ in. instead of "$\frac{5}{8}$ in. or thereabouts," as recommended by the Master Car-Builders' Association.

Ten or 12 years ago a paper was read at one of the meetings of that Association, calling attention to the great incongruity in the forms of the sections of rails and wheel-treads and flanges which then existed, and recommending that those portions of the rail-heads which come in contact with the flanges of the wheels should be made to conform to or fit the flanges, on the principle "that the wear of surfaces in frictional or rolling contact is in inverse proportion to their area."

This recommendation, the editor of *Engineering News* says, resulted in "a decided and widespread tendency to conform to this demand," which, he says further, "it is now all but unanimously admitted was wholly without any rational foundation."

This is followed by the observation "that Mr. A. M. Wellington . . . now claims the credit of having individually stopped an unchecked current of practice toward an alleged erroneous theory."

Our quotation marks have been carefully used.

Now what was this great stroke of genius of which the editor of *Engineering News* was the author, and on which he felicitates himself so complacently? His achievement consisted in substituting a radius of $\frac{5}{16}$ in. for describing the form of the corners of rail-heads for one of $\frac{1}{4}$ in. (which was the original proposition).

It recalls one of Thackeray's stories. When he was in this country he chanced to occupy the same seat with a loquacious passenger in a railroad car, who, on learning how famous a person his companion was, announced as his claim for distinction that "*my father was the first man who introduced c-o-l-d pressed castor-oil.*"

The report of the committee referred to above was received too late for a full discussion of it here, but we may have something more to say of it hereafter. Most of those who compose the committee which made the report before us are very able men. So far as we know, however, only one of them has had his chief professional training and experience in the department of mechanical engineering of railroads, and he is now in retirement. Most of the others are eminent civil engineers. Surely in the consideration of what may be called the conjunction of the civil with the mechanical engineering of railroads, the mechanic should have had some voice. While no criticism of the work of the committee will be attempted now, attention may be called to one fact—the original committee consisted of seven members, who recommended a radius of $\frac{1}{4}$ in. for the corners of the rails. When five new members were added to the committee, the radius was increased to $\frac{5}{16}$ in., or made 25 per cent. greater. The problem propounded is, if five additional civil engineers increase the radius 25 per cent., how much would it be increased if there were an equal representation of competent mechanical engineers on the committee?

NEW PUBLICATIONS.

BEESON'S INLAND MARINE DIRECTORY. By Harvey C. Beeson. (276 pp., $6\frac{1}{2} \times 9\frac{1}{4}$ in.) Detroit, Mich.

The first 29 pages of this work contain a table giving the class, name, tonnage, date when built, where built, name of owner or manager, and residence of owner or manager. The extent of the shipping interest on the great lakes may be known that this list includes over 1,800 vessels. Besides this there is a list of about 350 steam-vessels of under 5 tons burden. Another list of sailing-vessels includes over 1,300 of these. A variety of other data and information of interest to fresh-water mariners, of those interested in the traffic of the lakes, is scattered through the book. There are also a number of good and some indifferent half-tone engravings of lake steamers, yachts and sailing-vessels, and also a goodly number of advertisements.

THE COAL TRADE. *A Compendium of Valuable Information relating to Coal Production, Prices, Transportation, etc., at Home and Abroad, with many Facts worthy of Preservation for Future Reference.* (121 pp., 6×9 in.) By Frederick E. Saward, Editor of the *Coal Trade Journal*. New York.

This volume contains first a review of the coal trade for 1893. This is followed by a convenient table showing the annual production of coal in the United States and Territories for the years 1889, 1890, 1891, and 1892. In round numbers the total of this production was 132, 140, 150 and 155 millions of tons for the years respectively. Following this table is a series of sketches of the different coal-fields and their production, the traffic of the different cities. The latter part of the book contains a miscellaneous collection of information concerning coal and coal traffic of varying degrees of interest and value. The book does not seem to have any very well-defined

plan, and is a collection of miscellaneous data relating to the coal traffic, much of which is valuable and cannot be found in an equally convenient form elsewhere.

THE GREAT LAKES REGISTER OF SHIPPING; *also Rules and Tables of Scantlings for the Construction of Steel Ships.* (59 pp., $8\frac{1}{4} \times 11$ in.) By Joseph R. Oldham, N.A. and C.E., Chief Surveyor, Cleveland, O.

"The first part of this volume the author describes as "a book of rules for the construction of lake steamers, with formulæ for ascertaining the size of shafting for marine engines and estimating horse power and displacement; formulæ and rules for riveting joints; tables of weights of materials, areas of circles, etc.; and general particulars of construction, including dimensions of boilers, 'wheels,' cylinders, etc., of all the steel, iron and composite steamers on the Northwestern lakes." " The latter part is a register of shipping on the great lakes. In this all the vessels owned by different companies, firms and individuals are given under the names of such parties; the names of the vessels, whether screw or paddle, tonnage, dimensions, size and steam pressure of boilers, diameter and stroke of cylinders, diameter of screws, date when built, and where and by whom built.

The rules given for the construction of ships have apparently no other authority than that of the author. The data embodied in the tables will be of much interest and value to all who are concerned in the lake shipping.

THE OFFICIAL RAILWAY LIST. *A Complete Directory of the Presidents, Vice-Presidents, General Managers and Assistants, General and Division Superintendents, Chief and Assistant Engineers, Secretaries, Treasurers, Auditors, Traffic Managers, General Freight Agents, General Passenger and Ticket Agents, Baggage Agents, Superintendents of Telegraph, Purchasing Agents, Fuel Agents, Car Accountants, Superintendents of Motive Power, Master Mechanics, Master Car-Builders, Master Car Painters, Foremen of Repairs, Road-masters, etc., of Railways in North America, and Hand-book of Useful Information for Railway Men.* Twelfth Year. (479 pp., $4\frac{1}{4} \times 8$ in.) Chicago: Railway Purchasing Agent Company.

The title of this book is so long that it leaves but little room for any other notice. There seems of late to be a *penchant* for long titles in books, and some authors transfer their tables of contents to their title-pages. The practice cannot be commended.

Not much need be said of the excellent directory before us, excepting that it is bigger, has more names in it—and more advertising—than ever before. It has a stout, plethoric look of prosperity that will make some publishers envious. Those who want the names and addresses of railroad officials will find this one of the most convenient books which give that kind of information.

KNOTS, SPLICES, HITCHES, BENDS AND LASHINGS, *Illustrated and Described.* By F. R. Brainard, Ensign U. S. Navy. (76 pp., 4×6 in.) New York: Practical Publishing Company.

The title of this book describes its character. It illustrates and tells how to make a great many different kinds of knots, splices, hitches, bends and lashings with ropes of different kinds. The method of doing this is illustrated by a series of outline diagrams, not of the best kind, but sufficient for the purpose. It is intended not only for seafaring men alone, but for wayfaring men as well, who, it is said in the introduction, "may profit by the knowledge of the subject, and may with advantage put the knowledge to practical every-day use." The information it contains will also be relished and valued by yachtsmen, boatmen, and canoeists. It might be added that every mechanic, especially those who have anything to do with the erection of heavy work, would be greatly benefited by a knowledge of how to tie ropes most effectively.

The book contains directions for tying ropes in 128 different kinds of ways. This is followed by tables giving the circumference, weight per foot, working and breaking strength of hemp and iron and steel wire ropes. The tables are followed by 12 pages of definitions.

The book is considerably padded, to make as much showing as possible with a little matter. It is printed on very thick paper, the pages are small, each one having only 112 words, so that the whole book contains only 8,400 words. As the price of the book is $1, its contents might be quoted at 84 words for a cent, which makes this kind of knowledge come high.

BOOKS RECEIVED.

Professional Papers of the Corps of Engineers of the United States Army. No. 26.

Local Engineering Data for St. Louis. Compiled by the Engineers' Club of St. Louis.

The Compass. Vol. II. New York: William Cox, Editor; Keuffel & Esser, Publishers.

Poor's Manual of the Railroads of the United States for 1893. H. V. & H. W. Poor, New York.

Bulletin of the United States Geological Survey. Nos. 82, 83, 84, 85, 90, 91, 92, 93, 94, 95 and 96.

Electricity up to Date. Third Edition. By John B. Verity. New York: Frederick Warne & Company.

The Michigan Engineers' Annual, containing the Proceedings of the Michigan Engineering Society for 1893.

Molesworth's Pocket-Book of Engineering Formulæ. Twenty-third Edition. London and New York: E. & F. N. Spon.

The Law of Incorporated Companies Operating under Municipal Franchises. Vols. I, II and III. By Allen Ripley Foote. Cincinnati, O.: Robert Clarke & Company.

United States Geological Survey. By J. W. Powell, Director. Eleventh Annual Report, 1889–90. Part I, Geology; Part II, Irrigation.

The Chilean Revolution of 1891. By Lieutenant James H. Seares, U. S. N., and Ensign B. W. Wells, Jr., U. S. N., Washington, D. C.: Office of Naval Intelligence, Navy Department.

Monographs of the United States Geological Survey. By J. W. Powell, Director. Vols. XVII, XVIII and XX, with Atlas to accompany the Monograph on the Geology of the Eureka District, Nevada, by Arnold Hague.

TRADE CATALOGUES.

LIGHT CARS. Sheffield Car Company, Three Rivers, Mich.

CHAPMAN VALVE MANUFACTURING COMPANY'S CATALOGUE, 1893. Boston, Mass.

PITTSBURGH LOCOMOTIVE WORKS exhibit at the World's Columbian Exhibition.

General Catalogue of Worthington Pumping Engines, Steam Pumps and Hydraulic Machinery.

Catalogue of Railway, Steamship and Stationary Engine Appliances. J. T. Connelly, Milton, Pa.

Our Exhibit, World's Columbian Exposition. Brown & Sharpe Manufacturing Company, Providence, R. I.

Worthington Steam-Pumping Machinery at the World's Columbian Exhibition. Manufactured by Henry Worthington.

Frazer & Chalmers, of Chicago, send us over 30 different catalogues describing the various kinds of machinery they manufacture, which relates chiefly to mining and metallurgical operations.

Root Improved Water-tube Boiler, Abendroth & Root Manufacturing Company, New York. This is a six-page (6 × 15½ in.) folder, with excellent wood-cuts, illustrating this form of water-tube boiler. A concise description of the details of the boiler is appended.

The C. W. Hunt Company, of New York, have issued a descriptive catalogue (6¾ × 9½ in., 24 pp.) of their "industrial" railways. These are intended for mines and factories of all kinds. The book is elaborately illustrated. The same Company also send a description (8 pp.) of their exhibit at the Columbian Exhibition.

Brooks Locomotive Works, Dunkirk, N. Y., have also issued a descriptive volume (6¼ × 10 in., 30 pp.) of their exhibit at the Chicago Fair. It contains an engraving and historical sketch of their works, an announcement of the facilities which the Company has for doing work, and illustrations and dimensions of the locomotives they have on exhibition.

The Worcester Drill Grinder, manufactured by the Washburn shops of the Worcester Polytechnic Institute, Worcester, Mass. This is a small pamphlet (5¼ × 8 in., 20 pp.) describing the various kinds of drill grinders which are made at the shops of the Worcester Polytechnic Institute. It is illustrated with a number of good engravings, and gives sizes, prices and other information which a buyer will be likely to want.

E. W. Bliss Company, of Brooklyn, N. Y., have sent us a number of circulars (9 × 12 in) which describe the different kinds of presses made by them. One of these (8 pp.) describes the "Stiles" Drop Hammers. The others relate to Double-Crank Power Presses (20 pp.), Toggle Joint Drawing Presses (16 pp.), "Open-Back" Power Presses (12 pp.) and the "Stiles" Power Punching Presses (12 pp.). These are all illustrated with excellent wood-engravings, are well printed on coated paper, which does not smell bad, as the paper of some of the other catalogues we have noticed does.

The Weir Frog Company, Cincinnati, O., manufacturers of frogs, switches, crossings, etc.

The catalogue of this Company is quite an elaborate volume (4¾ × 8¼ in., 233 pp.), which opens on the short end. It is illustrated by a large number of excellent outline engravings which are made by the wax process, and also a considerable number of wood-cuts. As we have frequently pointed out, the best treatises on many subjects are now trade catalogues. The book before us is an example. While it makes no pretensions to an exhaustive treatment of the subject to which it pertains, there is a great deal of valuable information in it which cannot be obtained from any other source. The book concludes with a number of useful tables relating to turn-outs, switches, frogs, crossings, etc.

The Rogers Locomotive Company, Paterson, N. J. (8 × 11¼ in., 117 pp.) This Company has just issued a new catalogue of the locomotives they manufacture. It begins with a very brief history of the works, with engravings of them as they were in 1832 and as they are in 1893. This is followed by a general description, or rather blank general specifications of a locomotive. A very excellent and clear chapter on The Tractive Power of Locomotives is then given, with directions for calculating the tractive power of locomotives and the resistance of trains. The remainder of the book contains 50 engravings of the different types of locomotives built by this Company, with tabular statements of their dimensions and capacity. Most of the illustrations are very good half-tone engravings, although a few of them are wood cuts.

This same Company have also issued a descriptive pamphlet (6¼ × 11 in., 17 pp.) of their exhibit at Chicago. The different engines they have on exhibition are illustrated by very good half-tone engravings and diagrammatic views giving the principal dimensions of their locomotives. It gives, in a very convenient form, all the information which an engineer is likely to ask for who visits the exhibit.

New York Central & Hudson River Railroad Locomotives. Mr. William Buchanan, Superintendent of Machinery and Rolling Stock of this line, has just issued a very convenient little book (3 × 8½ in., 54 pp.) giving the general dimensions, weight, etc., of the locomotives on that road. It begins with a convenient table in which the speed in feet per second and the time in seconds per mile is given for different speeds per hour. Opposite this is a half-tone engraving of the Columbian flyer train, made from a photograph taken at full speed. After this is an engraving of the reproduced *De Witt Clinton* and its train, with the dimensions of that engine. A half-tone engraving and the dimensions of the celebrated engine 999 occupies the next pages. The rest of the book is occupied by 22 very convenient diagrammatic engravings of the different classes of engines used on the New York Central Railroad, with their dimensions arranged in tabular form. The book can conveniently be carried in the pocket, and altogether is a model of its kind. The only fault we can find with it is that the pages are not numbered, which might be an inconvenience in referring to them.

Catalogue and Testimonials of Cold Saw Cutting-off Machines, Newton Machine Tool Works, Philadelphia. This catalogue, which is a 60-page pamphlet, 6¼ × 9¼ in., will probably be a revelation to many readers, who will be surprised to find what a variety of the kinds of machinery which it describes is made. Twenty-two different kinds of such machines are illustrated, and a number of sizes of some of them are built. The manufacturers say:

"The Cold Saw Cutting-Off Machine has long since ceased to be an experiment, and has been proved by practical operation to be very much of a success, not only for cutting off round, square or flat bars, but for the general run of cutting and for forge work, architectural iron works, rolling mills and general machine-shop work. We know of no machine shop that has not work enough to make one of these tools pay for itself in a short time.

"The saws are hollow-ground, and are made in three grades of teeth: fine teeth for hard material; medium-sized teeth for ordinary work, and coarse teeth for heavy or soft stock. The saws run in a bath of oil or soda water, keeping them cold and lubricating the cutter."

COMPARISON OF THE PRACTICAL RESULTS OBTAINED BY THE USE OF THE WROUGHT-IRON FORGED WHEELS, AS MADE BY THE ARBEL'S ESTABLISHMENTS AND THE WHEELS OF SEVERAL AMERICAN TYPES. The Anonymous Manufacturing Society of the Arbel Establishments, Rive de Gier, France. (6 × 9½ in., 52 pp.)

To a very considerable extent this pamphlet is descriptive of the exhibit of the Arbel's Establishments at the Columbian Exhibition. It also gives a historical sketch and description of the works, and "a few words"—which are descriptive—"on other systems of wheels." An interesting historical notice on the Wrought-Iron Wheels is also given, with a description of the method employed at the Couzon's Works in France, which are the Arbel's establishments. The last part of the volume contains a dissertation on Railroad Wheels by M. L. Durant, and gives the results of tests made upon the request and according to the indications of Mr. Ernest Polonceau, Chief Engineer of Machinery of the Orleans Railway. The object of the pamphlet is to show the superiority of the Arbel wrought-iron wheels over others in use in this country and elsewhere. The merits of wrought-iron wheels do not seem to have ever been fully appreciated in this country. Their record of service, endurance and reliability in Europe should be an interesting and profitable study for American railroad engineers.

EXHIBIT OF LOCOMOTIVES BY THE BALDWIN LOCOMOTIVE WORKS, Philadelphia. What has been said of the Brooks and Rogers exhibition volume might almost be repeated of the one which the Baldwin Company have issued. Theirs is, however, larger than either of the others (7¾ × 10½ in., 78 pp.). The frontispiece to the book is a half-tone engraving showing the interior of their erecting shops, and another engraving shows the outside of their works.

The first chapter is a sketch of the history and capacity of their establishment. In all 13 locomotives are illustrated and described. Of these more than half are of the Vauclain compound type. The engraving, printing and paper are all excellent.

There is one criticism of the engravings in this and in the Brooks volume which we think might be justly made. The photographs were nearly all taken from a point a little in front of the engines, and they are shown on an angle looking toward the back end. The result is that the size of the smoke-boxes, chimneys and trucks are all exaggerated in relation to the other parts, and the effect is somewhat the same as when a countryman has his picture taken and protrudes his hands and feet too far forward. The picture of the magnificent *Decapod* engine, opposite page 63 of the Baldwin catalogue, as an example, looks—to speak in convivial vernacular—as though it had been on a "tear" and was suffering from a "swelled head." The front of the engine, including the smoke-box, chimney, etc., which are not its most impressive parts, are exaggerated, and the imposing proportions of the engine are to a considerable extent lost. The same thing is true of the view of the "double-ender" opposite page 17, and to a less degree of the *Columbia* on page 26. The great driving-wheel sof this machine, grouped close together under the middle of the boiler, are the most striking features of this machine. If the camera had been placed exactly opposite to these, they would have had their full value in the picture, and the front and back ends of the engine would have appeared in their proper relation to the other parts. As it is, the front truck wheels of the *Columbia* are shown much larger than the back ones, which give the representation of this engine a sort of bobtailed appearance which takes away much of its dignity. The most striking view of a locomotive, it is thought, is a square side elevation, and if such a photograph could be made, which would be an orthogonal projection, it would make the most effective picture which could be taken.

DESCRIPTIVE AND ILLUSTRATED CATALOGUE (4¾ × 6¾ in., 390 pp.) OF THE PRATT & WHITNEY COMPANY, Hartford, Conn. This is a new catalogue recently issued by this well-known company, who are engaged in the manufacture of the lighter classes of machinists' tools. The extent of their facilities for doing work may be known from the following extract from the preface of the book before us:

"In the machine shops are 400 lathes of various kinds, 115 planers, 85 drilling machines, 120 milling machines, 18 screw machines, 13 gear and rack cutters, 10 boring mills, and 200 other machines, in addition to the tools used in the pattern shop. When all these are running the concern can give employment to about 950 men."

To give an idea of the kind of work which this Company does, we would be obliged at least to copy the index to its catalogue. This occupies 5½ pages, and is little more than an enumeration of the different kinds of tools which are manufactured. Nearly every page of the book has an engraving on it, some of them more than one, so that the catalogue contains nearly or quite 400 engravings. These are all wood-cuts, the great majority of which are of the best kind, although here and there the trace of process work may be seen.

Looking over the pages of this book and the knowledge thus acquired of the elegant tools and appliances supplied by this Company will or should stir the mechanical soul—if there is such a thing—of any good machinist to its very profoundest depths.

The book has been published in a very convenient form, and is filled with useful information from one end to the other.

LOGARITHMIC TABLES. By Professor George William Jones, of Cornell University. Fourth Edition. London: Macmillan & Company; Ithaca, N. Y.: George W. Jones.

This work is a new edition of the logarithmic tables of Professor Jones, which have been before the public for several years. It is entirely reset in new type, with a larger page, and is a decided improvement over the previous issues. The logarithms and other tabular functions are given to six decimal places, and the author has partly obviated the objection, often made with much justice to such tables, that interpolation is difficult, by giving on the margin multiples of the differences. In the early part of the table, however, all these could not be printed in the space at disposal, and hence all objections are not fully removed. It is our opinion that logarithmic computations are most satisfactorily made, either with five-place or seven-place tables, but the work of Professor Jones is certainly one of the best six-figure tables with which we are acquainted.

THE JACK'S RUN VIADUCT.

To the Editor of the AMERICAN ENGINEER:

DEAR SIR: I have seen in your July edition a description and illustration of the Jack's Run viaduct, which has been put up lately under my direction in the vicinity of Pittsburgh for an electric road of the Pleasant Valley Railroad Company. The article contains a good many errors, and I consider it therefore my duty to correct some and add a few additional facts, which you will be kind enough to publish in your next issue.

After the company had already several bids and plans for said viaduct I was appointed to take charge of the work. The cheapest plan was accepted under the condition that same would be approved by the engineer. After a correct survey and lay out for the pillars a recalculation for the whole structure was made.

The trestle posts were made more rigid by increasing the latter from $\frac{1}{16}$ to $\frac{1}{8}$ and by substituting stiff cross-braces for rods. Various other sections have been increased, and after specifications for substructure and superstructure had been prepared, the contract price was altered accordingly and details worked out under my supervision.

As will be seen by the formulæ (in July edition) the viaduct was constructed very economically. Said formulæ are unhappily given wrong, but any bridge engineer may easily correct them.

The viaduct is owing to the stiff cross-bracing very rigid, and the electric cars run over it with unrestricted velocity.

The cost of the structure, including everything, is about two-thirds of the figure as given in your July issue.

The viaduct was to be constructed within three months from the time the contract was let, but owing to a severe winter it took just four months longer.

Truly yours,

PITTSBURGH, PA. HERMANN LAUB, C.E.

NOTES AND NEWS.

A Correction.—In our last issue, on page 366, we illustrated a safety plate under the running board, and credited the same to the Southern Pacific Railway. It should have been credited to the Canadian Pacific; and a letter received from the mechanical department states that they have never had an occasion where one of these plates has been pierced.

Large Steel Plates.—Some of the largest steel plates ever made in England have been turned out at the works of the Cousett Iron Company, Durham. They measure 60 ft. 2 in. in length, 50 in. in width, and $\frac{11}{16}$ in. in thickness. They are for use in the construction of some large cattle ships which are being built at West Hartlepool for a firm in the United States.

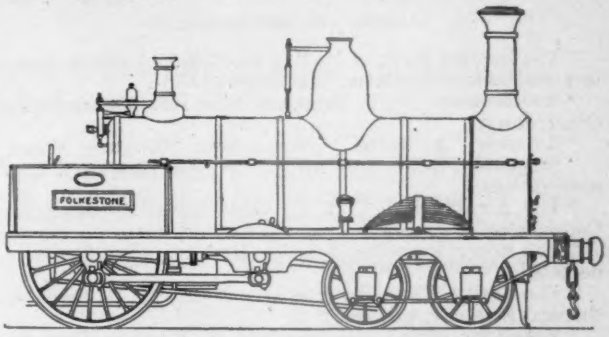
Franklin Avenue Freight Station in St. Louis.—In publishing the engravings and description of this structure last month, one of the most important facts in relation to it was omitted, which was that it was designed and built under the supervision of Mr. George S. Morison, C.E., whose office is in the Temple, Chicago. This omission was accidental, and we apologize for the oversight to all and everybody to whom our apologies are due.

Air-brakes for Street Cars.—For some time past a street railway company of St. Louis, Mo., has been making careful tests of air-brakes on six of its cars, and the test is said to have been so successful as to warrant its adoption. The brake is the same in principle as that used on steam railways, with the exception of the method of pumping the air. This is done by a pump attached to the axle of the car. As the axle revolves it operates the air-pump by means of cogs. The maximum pressure is 40 lbs. to the inch, and this can be obtained while the car is running a distance of 200 ft. The car can be stopped 10 times in the space of one block without exhausting the air.

The Great Mersey Bridge.—Plans have been drawn up for what, when finished, will be one of the world's greatest bridges. This new structure is to cross the river Mersey at Liverpool. It will be of arched suspension type in three spans, the roadway being suspended from an arch. Each span will have a clear waterway of 1,000 ft., the center span having a clear headway of 150 ft. above high water of ordinary spring tides. The bridge will allow for a roadway 40 ft. in width, sufficient for at least four lines of wheel traffic, and two outer footways, each 7 ft. 6 in. wide, the roadway being laid with wood and the footpaths with granolithic pavement. In addition to the provision for ordinary wheel and passenger traffic, an overhead electric tramway is to be constructed along the center of the road.

Naval Premiums.—A calculation has been made at the Navy Department in regard to the premiums paid to builders of naval vessels during the present year. Beginning with the *Bancroft* in January, the Government paid her constructors, the Moores, of Elizabethport, N. J., $45,000 for exceeding her speed. Then followed the *Detroit*, which earned $150,000 for the Columbian Iron Works, of Baltimore. The *New York* came next with the largest sum won yet, when, by reeling off 21 knots, or one better than called for, she won $200,000. The *Machias*, by her fine performance, also gained $45,000 for the Bath Iron Works. The *Columbia*, which will have her speed trial in the next month, may also gain a large bonus for the Cramps, but this will be a more difficult thing than winning $200,000 on the *New York*. The *Columbia* will have to make 21 knots an hour to fulfill the contract, and to get her speed up a knot better will require an enormous and continuous burst of steaming qualities.

The Folkestone Locomotive.—Mr. Clement E. Stretton recently sent the following data regarding the Folkestone locomotive, which we illustrate, to the *English Mechanic*, to whom we are indebted for the engraving.



The engine has inside cylinders, an intermediate crank-shaft without wheels, and a driving-wheel of 6 ft. diameter. On the South-Eastern Railway it took 44 tons at an average of 65½ miles an hour, and attained 73½ on a falling gradient.

The eight engines of this class afterward had the second pair of leading wheels removed, and a pair of driving-wheels placed upon the crank-axle. Thus converted to four wheels coupled engines, they continued at work many years.

Determination of the Quality of Vulcanized Rubber.—M. Vladimiroff recently read a paper before the Technical Institute of St. Petersburg, giving the results of his experiments which were made for the purpose of establishing rules to be followed in determining the quality of vulcanized rubber. He stated that chemical analysis was unsatisfactory, and that all tests should relate to the physical properties. From a long series of experiments he reached the following conclusions, from which the regulations of the Russian Navy relative to the acceptance of vulcanized rubber will be made:

1. Rubber ought not to give the slightest sign of cracking when bent double, after having been left for five hours in a closed air-chamber where the temperature is 125° C. The pieces used for the test should be $2\frac{3}{8}$ in. thick.

2. Rubber should not contain more than one-half of its own weight of the metallic oxides, and should stretch to five times its own length before breaking.

3. Rubber which is free from all foreign matter with the exception of the sulphur which has served for its vulcanization should stretch seven times its original length before breaking.

4. The permanent stretch measured immediately after rupture, should not be more than 12 per cent. in excess of the length of the piece as it was first submitted to the test. These test pieces should be about $1\frac{1}{4}$ in. long, $\frac{1}{4}$ in. to $\frac{1}{2}$ in. wide, and $\frac{1}{4}$ in. or more thick.

5. The suppleness can be determined by calculating the percentage of ash obtained by incineration; this determination can also furnish the basis of the choice which is to be made between different rubbers for various uses.

6. Vulcanized rubber ought not to harden under the action of low temperatures.—*Revue Scientifique.*

THE CONFERENCE ON AERIAL NAVIGATION.

By A. F. Zahm.

Among the various congresses recently assembled at the Memorial Art Palace, the International Conference on Aerial Navigation, held under the auspices of the General Engineering Congress, proved beyond expectation interesting and successful. Some 45 papers were contributed, covering many of the problems of aeronautics and aviation, and presenting the observations and results of experiments of experts in many countries of the world.

The effort of the committee to secure the co-operation of serious and capable men, to accumulate facts and positive knowledge rather than speculations or descriptions of projects, was abundantly rewarded, as the following programme will indicate :

TUESDAY, AUGUST 1st.

HALL 7-2.30 P.M.

AERIAL NAVIGATION CONFERENCE.

Opening Address :

O. CHANUTE, Chairman Organizing Committee.

SCIENTIFIC PRINCIPLES—JOINT SESSION.

PAPERS AND DISCUSSIONS.

"The Internal Work of Moving Air," S. P. Langley, Secretary Smithsonian Institute, Washington, D. C.
"Anemometry," S. P. Ferguson, Blue Hill Meteorological Observatory.
"Aviation," A. Goupil, Civil Engineer, Narbonne, France.
"Supporting Surfaces in Air," C. W. Hastings, Civil Engineer, deceased.
"The Air Propeller," H. C. Vogt, Naval Experimenter, Copenhagen, Denmark.
"The Screw Propeller," C. W. Hastings, Civil Engineer, deceased.
"The Elastic Fluid Turbine as a Motor," J. H. Dow, Mechanical Engineer, Cleveland, O.
"Motors for Flying Machines," C. W. Hastings, Civil Engineer, deceased.
"Materials of Aeronautic Engineering," R. H. Thurston, Director Sibley College, Ithaca, N. Y.
"Strength of Aeronautical Materials," G. Crosland Taylor, F.R.G.S. and A.I.E.E, Helsby, England.
"Forms for Flying Machines," C. W. Hastings, Civil Engineer, deceased.
"Behavior of Air Currents," George E. Curtis, Smithsonian Institute, Washington, D. C.
"Meteorological Observations," H. A. Hazen, Weather Bureau, Washington, D. C.

WEDNESDAY, AUGUST 2D.

HALL 7-2.30 P.M.

AERIAL NAVIGATION CONFERENCE.

SECTION A—AVIATION.

PAPERS AND DISCUSSIONS.

"Observations of Birds," G. Crosland Taylor, F.R.G.S. and A.I.E.E., Helsby, England.
"Gliding Flight," J. Bretonniere, Engineer and Observer, Constantine, Algeria.
"Soaring Flight," E. C. Huffaker, Observer, Bristol, Tenn.
"Sailing Flight," C. W. Hastings, Civil Engineer, deceased.
"Theory of Soaring Flight," Ch. de Louvrie, Engineer, Combebizou, France.
"Theories of Soaring and Sailing," G. Crosland Taylor, F.R.G.S. and A.I.E.E., Helsby, England.
"Theory of Sailing Flight," A. M. Wellington, Editor *Engineering News*, New York City.
"The Advantage of Beating Wings," Ch. de Louvrie, Engineer, Combebizou, France.
"Equilibrium of Flying Machines," C. W. Hastings, Civil Engineer, deceased.
"The Equipoise of Flying Machines," A. F. Zahm, Professor Nôtre Dame University, Indiana.
"Experiments in Flying Machines, Motors, and Cellular Kites," Lawrence Hargrave, Experimenter, Sydney, New South Wales.
"Suggestions and Experiments," F. H. Wenham, Engineer, Goldsworth, England.
"Methods of Experimentation," A. P. Barnett, Experimenter, Kansas City, Mo.
"Learning How to Fly," C. E. Duryea, Mechanical Engineer, Peoria, Ill.
"A Programme for Experiments," L. P. Mouillard, Observer, Cairo, Egypt.
"Gliding or Soaring Devices," G. Crosland Taylor, F.R.G.S. and A.I.E.E., Helsby, England.
"Various Experiments," E. C. Huffaker, Observer, Bristol, Tenn.
"Experiments with Hexagon and Tailless Kites," W. A. Eddy, Experimenter, Bayonne, N. J.
"Kite Experiments," J. Woodbridge Davis, New York City.
"Flexing of Bird's Wing in Flight," B. Baden Powell, Lieutenant Scotts Guards, England.
"Designing of Flying Machines," J. D. Fullerton, Major Royal Engineers, England.

THURSDAY, AUGUST 3D.

HALL 7-2.30 P.M.

AERIAL NAVIGATION CONFERENCE.

SECTION B—BALLOONING.

PAPERS AND DISCUSSIONS.

"Manufacturing Hydrogen Gas Balloons," C. E. Myers, Aeronautical Engineer, Frankfort, N. Y.
"Natural Gas Balloon Ascensions," C. E. Myers, Aeronautical Engineer, Frankfort, N. Y.
"Flotation *vs.* Aviation," Professor de Volson Wood, Stevens Institute, Hoboken, N. J.
"Navigable Balloon Flight," C. W. Hastings, Civil Engineer, deceased.
"Manœuvring of Balloons," C. E. Myers, Aeronautical Engineer, Frankfort, N. Y.
"Systematic Investigation of Upper Air," M. W. Harrington, Chief of Weather Bureau, Washington, D. C.
"Balloon Signals," Ch. Labrousse, Aeronaut, Paris, France.
"Observations from Balloons," C. C. Coe, Aeronaut, Ridge Mills, N. Y.
"Balloon Meteorology," C. E. Myers, Aeronautical Engineer, Frankfort, N. Y.
"Design of Navigable Balloon," General W. Hutchinson, British Army, Silverdale, England.
"Ten Miles up in the Air," De Fonvielle, Paris.

Mr. O. Chanute, Chairman of the Organizing Committee and of the first day's meeting of the Conference, announced in his opening address that the purpose of the Congress was to collect and place on record the knowledge obtained since the last similar international congress, held at Paris in 1889, to give students and experimenters an opportunity of meeting and corresponding, and to promote concert of action among the various persons who take an interest in the problem. He gave substantially a summarization of the progress thus far attained in the propulsion of balloons and in the construction of flying machines, stated the probable limitations in the capacity and usefulness of each, and indicated the proper character and domain of future effort. He said :

"It is well to recognize from the beginning that we have met here for a conference upon an unusual subject; one in which commercial success is not yet to be discerned, and in which the general public, not knowing of the progress really accomplished, has little interest and still less confidence.

"The fascinating, because unsolved, problem of aerial navigation has hitherto been associated with failure. Its students have generally been considered as eccentric; to speak plainly, as "cranks;" and yet a measurable success is now probably in sight with balloons—a success measurable so far that we can already say that it will probably not be a commercial one —while as to flying machines proper, which promise high speeds, we can say that the elements of an eventual success, the commercial uses of which are not as yet very clear, have gradually accumulated during the past half century.

"The present is, I believe, the third international conference on aerial navigation. The second took place in Paris in 1889, and a fourth is projected to take place in that city during the Exposition of 1900.

"The Conference of 1889 undoubtedly forwarded the solution of the problem, by making the public aware that a number of sane men were studying it in various parts of the world, by making these men acquainted with each other's labors, and by disseminating information concerning the scientific principles involved, the mechanical difficulties to be surmounted, and the practical details of aerial construction generally. Probably as a consequence of this very considerable advance has been made during the last four years, as will be indicated hereafter, and a number of promising proposals are now in progress of experiment and development.

"We may fairly expect similar results to follow from the present Conference. We may hope to collate here considerable knowledge concerning the scientific principles involved,

to gain information concerning the latest researches, and to establish some concert of action.

"Success, when it comes, is likely to be reached through a process of gradual evolution and improvement, and the most that we can hope to accomplish at present is to gain such knowledge of the general elements of the problem as to enable us to judge of the probable value of future proposals, both as mechanical or as commercial enterprises.

"More important still, we may perhaps help to enlighten a number of worthy but ill-equipped inventors who are re-trying old experiments, with no proper understanding of the enormous mechanical difficulties involved."

Referring to the prospect for dirigible balloons, he continued:

"The conditions as to resistance, lifting power, propellers and motors are now pretty well known, the speeds can be calculated with approximate accuracy, and while improvement can doubtless be achieved in the energy of the motor, in the efficiency of the screw, and especially in the form of the navigable balloon to diminish the resistance, it may be affirmed with confidence that railway express-train speeds cannot be attained with balloons of practicable dimensions. They may be used for war purposes or for exploration, but while we may say that the balloon problem is approximately solved, we may also say that the solution does not promise to become a commercial success, or to yield a large money reward to inventors."

With reference to aviation, he said:

"It is a mistake to suppose that the problem of aviation is single problem. In point of fact it involves many problems, each to be separately solved, and these solutions to be then combined. These problems pertain to the motor, to the propelling instrument, to the form, extent, texture and construction of the sustaining surfaces, to the maintenance of the equipoise, to the methods of getting under way, of steering the apparatus in the air, and of alighting safely. They each constitute one problem involving one or more solutions, to be subsequently combined, and these are the elements of success already alluded to as having gradually accumulated, which I propose to pass in review, more particularly to appreciate what has been accomplished since 1889."

Having noticed each of these problems in turn, he concluded:

"I hope you will agree with me that some of the elements of success have gradually been accumulating, and that there has been real, substantial advance within the last five years. There is still much to be done, but a number of experimenters have each been working on one or more of the problems involved, and they have made it more easy for others to forward the solution still farther.

"From this brief review of recent progress it would appear less unreasonable than it seemed a few years ago to hope for eventual success in navigating the air, and it may now be reasonably prudent to experiment upon a small scale, particularly if the inventor does so at his own expense; for the chances of commercial success seem still too distant to invite others to engage in the actual building of a flying machine, unless they do it with the understanding that they may lose their money. This is the course which has thus far been followed by the three or four experimenters who now seem in the lead, and it may not be long before they achieve such success as fairly to warrant them in proceeding to the construction of a full-sized machine.

"In any event, without concerning ourselves with the possible commercial use of such apparatus, we may hope here to advance knowledge upon this interesting problem, and to be of service to those ingenious men who are seeking for its mechanical solution."

The presiding chairmen of the meetings were: on the first day, Mr. Chanute; on the second, Dr. Thurston, of Cornell University; on the third day, Colonel King, of the U. S. Army. The papers contributed were mostly presented in very brief abstract, being entirely too long and too numerous for a full reading.

At the conclusion of the third meeting Mr. Chanute, wishing to inaugurate a practical application of the knowledge thus far accumulated, volunteered to be one of 20 persons to subscribe each $1,000 to an experimental fund, for the purpose of trying such scientific experiments, to be approved by a board of experts, as might be deemed likely to result in eventually accomplishing mechanical flight.

On motion of the secretary a fourth meeting was arranged for the following day, in which no papers were read, but the many topics already presented were further discussed. In this meeting Mr. D. Torrey, of Detroit, presented a plan for furthering Mr. Chanute's proposition, and Mr. C. D. Mosher, the builder of the fast yacht *Norwood*, informed the meeting of his achievements with light, powerful steam-engines, and of their probable value for aeronautical purposes.

An encouraging feature of the congress was that great interest in the success of its meetings and in the publication of its proceedings was manifested by prominent and capable engineers and scientists. Letters of cordial interest or contributions to the papers were received from the British Aeronautical Society, the Aerial Navigation Society of France, the Aviation Society of Munich, the Imperial Aeronautical Society of Russia, and the Aviation Society of Vienna. It is probable that the success of this Conference will lead to the formation of an American aerial navigation society, and also it is to be hoped to substantial and well-directed attempts of a practical nature.

AMERICAN AND ENGLISH LOCOMOTIVES.

(*Continued from page 374.*)

OUR engravings this month represent the smoke-boxes, steam and exhaust-pipes, and spark-arresting devices of the two engines which have been the subjects of this series of articles.

The specifications for these parts for the English engine are as follows:

SMOKE-BOX TUBE-PLATE.

The smoke-box tube-plate is to be ¾ in. thick, the tops and sides of the plate being turned forward 2⅞ in., forming a flange for the smoke-box, and is to be secured to the boiler barrel by a continuous weldless ring of angle steel well annealed, and supplied by makers to be approved by the Railway Company's Locomotive Superintendent. The ring must be faced, bored, and turned on the edges, and then shrunk on the boiler barrel, and is to be double riveted to the same, the rivets being placed zigzag. The tube-plate is to be faced where it is joined to the boiler steel angle. Eight wash-out plugs are to be inserted in the plate, as shown on the drawing.

SMOKE-BOX.

The smoke-box is to be of the form and dimensions shown on drawing. The sides and crown are to be $\frac{5}{16}$ in. thick, riveted to the flange of the smoke-box tube-plate. The front plate is to be in one and ⅝ in. thick. An angle-iron 2½ in. by 2½ in. by ½ in. thick is to be riveted to the front and side-plates. A hole for the door is to be cut in the front plate 3 ft. 10 in. diameter. The door is to be of Best Staffordshire iron ⅜ in. thick, protected on the inside with a shield, placed 1⅞ in. from door. Great care must be taken that the door when closed is made a perfectly air-tight joint. The cross-bar is to be made to lift out of forged brackets, which are to be riveted to the inside of the front of the smoke-box. Two handles and a gripping screw are to be provided. All the plates are to be clean and smooth and well ground over. All rivets are to be ⅞ in. diameter, pitched as shown on drawing, and are to be countersunk and filed off flush. The outside handles are to be finished bright. All lamp-iron brackets are to be fixed as shown.

CHIMNEY.

The barrel of the chimney is to be of good smooth Best Best Staffordshire iron ¼ in. thick, to have a butt joint, and is to be riveted together with countersunk rivets down the back, having a hoop of half round iron at the top; the bottom is to be of Best Yorkshire iron or mild steel plate ⅝ in. thick, perfectly free from hammer marks, and accurately fitted to the smoke-box. The height of the top of the chimney from rails is to be 13 ft. 2⅝ in.

STEAM-PIPES.

The steam-pipes in the smoke-box are to be of copper No. 6 Standard W. G., and 4 in. inside diameter, to have gun-metal flanges at both ends properly brazed to the pipes and accurately faced so as to secure steam-tight joints. Each steam-pipe is to be led to the cylinder, and is to be secured to the same with studs and brass cover-ended nuts.

VORTEX BLAST-PIPE.

The blast-pipe to be Adam's patent vortex, of the form and dimensions shown in the drawing, with an annular exhaust. The blast-pipe is to be secured to the cylinder with studs and brass cover-ended nuts.

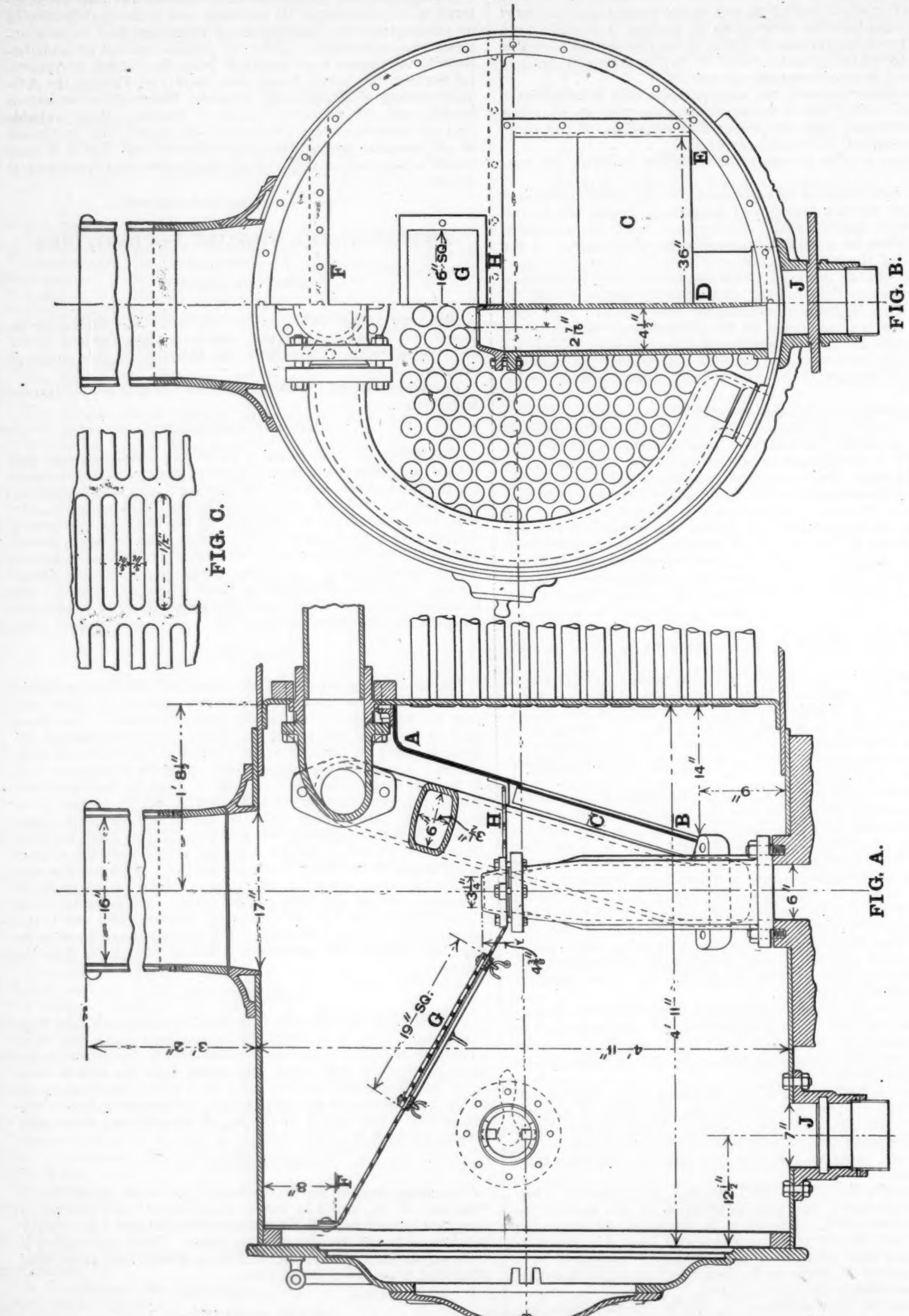


FIG. A. FIG. B. FIG. C.

SMOKE-BOX FOR AMERICAN EXPRESS PASSENGER LOCOMOTIVE.

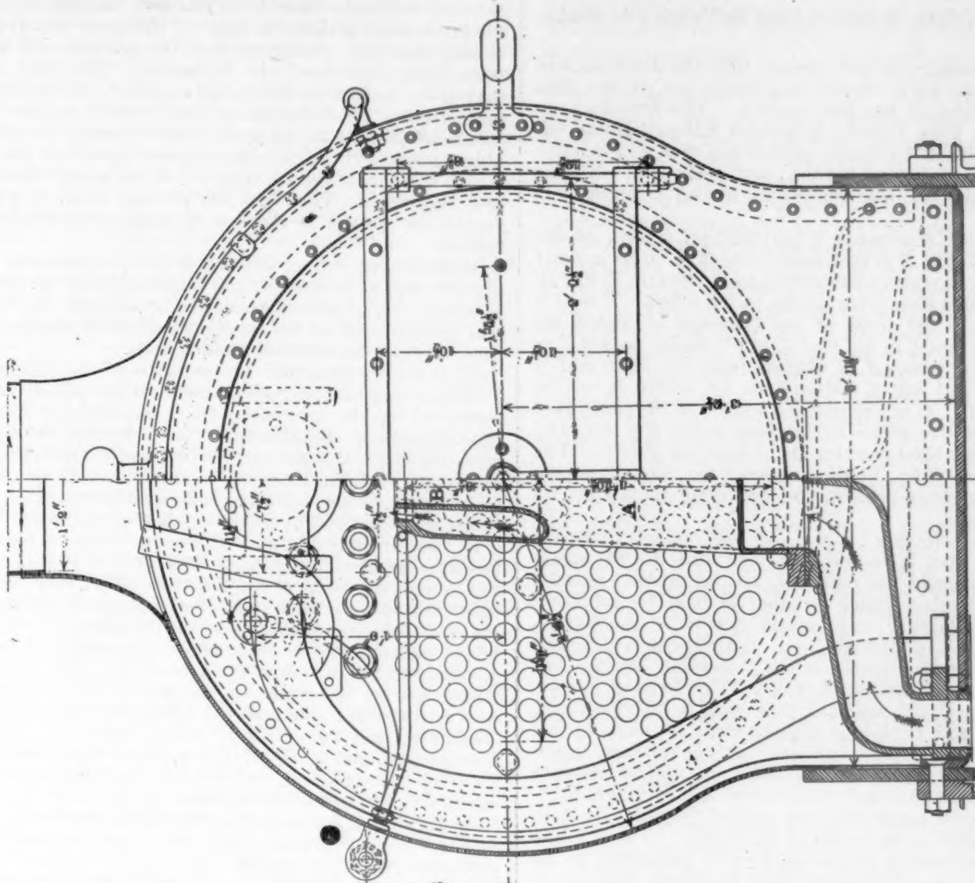


FIG. E.

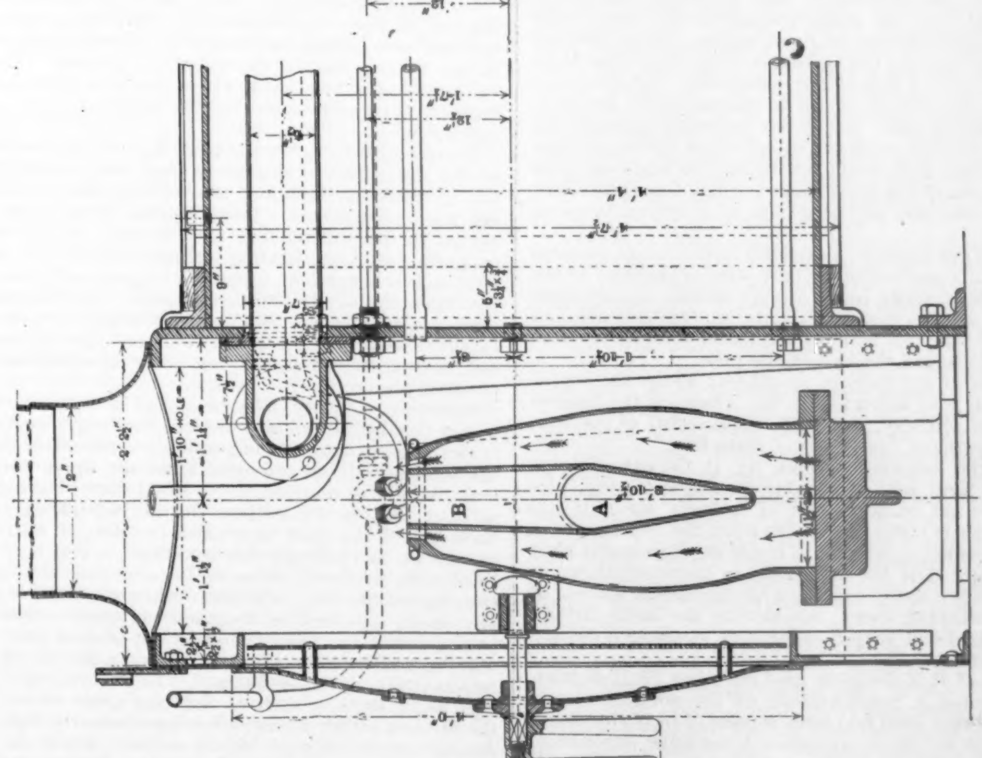


FIG. D

SMOKE-BOX FOR ENGLISH EXPRESS PASSENGER LOCOMOTIVE.

The specifications for the American smoke-box are briefly as follows:

STACK.

Smoke-stack straight, deflecting plate and netting in smoke-box.

From our engravings it will be seen that the differences in construction in the parts therein illustrated are greater than in any other portions of the two engines. The American engine for the New York Central & Hudson River Railroad has the cylindrical form of extended smoke-box now so generally used in this country, with deflecting and perforated plates to arrest sparks, while the English engine has no arrangements of this kind.

In fig. A, which represents a longitudinal section of the American smoke-box, *A B* is a solid deflecting plate in front of the tubes, and extending downward to the line *D E*, fig. B. *C* is a sliding-door which gives access to the tubes. *F G H* is a perforated plate, the form of the openings in which are shown in a larger scale in fig. C. *J* is a "cinder pocket," as it is called, for the removal of cinders from the front end of the smoke-box, and has a sliding-door by which it can be opened and closed. *G* is a removable section of the perforated plate, arranged to give access to the space above *F G H*. The exhaust pipes and blast nozzles are double, as shown. The steam-pipes are cast iron, whereas those of the English engine are copper. The other parts in the American smoke-box require no description.

The English smoke-box, it will be seen, is not extended further forward than is required to give room for the steam and exhaust pipes and the chimney, and, as already pointed out, has not deflecting plates or other devices for arresting sparks. The rectangular form of the bottom of the smoke-box and the method of fastening the cylinders to it is lighter than the corresponding parts on the American engine, but they are also more expensive to make. This form of smoke-box was very generally used in this country 25 years ago. Rogers, Winans and Hinkley's engines were all made in this way. The cylindrical smoke-box was used by William Mason as early as 1855 or 1856. He attached a separate cast-iron saddle to the smoke-box, and then bolted his cylinders to it. Later cylinders were made with one-half of the saddle cast on each one, and united in the center of the engine. This method is now almost universally employed here in preference to the rectangular plate iron smoke-box, with cylinders attached to it. It is thought that the cylindrical smoke-box, with cylinders having half saddles cast on them, makes a much cheaper and stronger job than the old-fashioned plan, and it would be difficult now to induce any of our locomotive builders to go back to the old plan, which is still in general use in England. Of course the use of plate frames has had more or less influence in leading English engineers to adhere to the rectangular form of smoke-box, as it would not be easy to adapt our plan of half-cylinder saddles to plate frames, which fact shows how interdependent one part of the design of a locomotive is on another.

It of course is not possible to establish without any question which method of construction is best—the cylindrical or the rectangular form of smoke-box. It may be said, though, that the opinions of *all* locomotive builders, superintendents, and master mechanics in this country are unanimous in favor of the cylindrical form and the half-saddle plan.

The engraving of the English smoke-box shows the vortex blast-pipe, which is an invention of Mr. Adams of the London & Southwestern Railway. A little explanation of its construction may, perhaps, not be out of place here.

As shown in the longitudinal plan, fig. D, the exhaust pipe is of bifurcated form, with an annular opening at the top. Its general shape is not unlike a pair of trousers, the two legs being united at their lower ends. Between the two legs is an opening *A*, extending upward to *B* inside of the annular blast nozzle at the top. The air and smoke is therefore drawn or forced upward not only by contact with the outside surface of the current of escaping steam, but also by the inside surface of what is a cylindrical shaped column of steam as it escapes from the blast orifice.

To what extent this device is used on other English roads besides the London & Southwestern we are not able to say, but we have received such favorable reports of its performance on that line, that we think American locomotive superintendents should recognize its merits or at least give it a trial. It should be added that it is patented in this country, but doubtless favorable arrangements can be made with the inventor for its use by those disposed to try it.

(TO BE CONTINUED.)

THE BORK CONSTRUCTION OF LOCOMOTIVE BOILER.*

It is a remarkable fact that the locomotive boilers built for the first railroads have been retained unchanged as the type for later constructions, in spite of the great disadvantages resulting from the arrangement of the fire-box, and which have been recognized from the beginning. The large number of stay-bolts and braces which are required, the universal use of flat surfaces for the sides of the fire-box, against which the steam pressure acts, the great cost of construction, its favorable arrangement for the deposition of scale and the difficulties which it presents for the removal of the same, should all militate against it. Then the thicker the layer of scale that is found, the greater is the loss of evaporative efficiency of the boiler.

Moreover, as copper has, up to the present time, been principally used in Europe for the construction of the fire-box, and that, too, at a great expense, it has been found that the renewal and maintenance of the same costs from 20 per cent. to 25 per cent. of the total expense of all repairs.

Thus the renewal and maintenance of the fire-box, besides adding a very considerable amount to the repair account, also serve to keep the locomotive for a considerable length of time out of service. Besides this, even with the most scrupulous care, the fire-box must always be considered as the most dangerous part of the locomotive, and it is well known that the great majority of locomotive boiler explosions take place either in the fire-box itself or the outer shell of the same.

If, then, in spite of this well-known defect, no radical change has thus far been recognized, it is natural to seek for the reason in the circumstances of the case, which may rest upon the universal opinion that a sufficient supply of steam can in no way be so well obtained as in the locomotive type of boiler, where the combustion takes place in an enclosed fire-box, and a portion of the heat developed is radiated directly against the sheets wet by the water in the boiler. This supposition, as well as the other conventional method of viewing the matter—namely, that the efficiency of a locomotive is in a general way proportional to its heating surface—was shown in 1870 to be without foundation, and this was confirmed by experiments made with brick-lined locomotive fire-boxes on the Hungarian State Railways, formerly the Thuringian Railway, and on the Swedish State Railways; but these experiments did not give perfectly conclusive results.

On a suggestion which I made before the Society of Railway Science, in 1890, a locomotive, No. 834, with a brick-lined fire-box has been built at the Tempelhof Works, and has been submitted to very careful experiments this year. From the results obtained, the opinion which has been held regarding the standard form of fire-box must be recognized as being entirely untenable.

It must now be acknowledged that the attainable efficiency of the locomotive is at least as high with the brick-lined fire-box as with any boiler of the ordinary form that has thus far been constructed. Furthermore, it has been shown, in regard to the opinion that the efficiency of a locomotive is proportional to the heating surface, that it is at fault. This efficiency is dependent, as further experiments have shown, on the intensity of the heat produced. The heating surface, therefore, only enters into the consideration of the case to the extent that it must be sufficient to cool the gases of combustion, so that these latter do not enter the smoke-box at a temperature above 575° F.

Construction of the New Boiler.—The new construction of locomotive boiler, which was built for freight engine No. 834, is clearly shown by our engravings. Instead of the ordinary fire box there is an extension from the upper portion of the shell, which is retained in its usual form, leaving the outer shell of the fire-box without further modification, while the back end of the shell terminates in a sort of water tube, and instead of the ordinary fire-box there is one built up of and lined with fire-brick, so as to form a space similar to that of the original fire-box. For cases where the shell is proportionally short, it is best to lengthen the same somewhat at the back; and it has been found by experiment that this length will be sufficient in all cases where a length of tubes of 4 meters (13 ft. 1½ in.) is obtained. Engine No. 834 has a rather high outer fire-box shell, so that the space above the arch of the fire-box proper is somewhat unnecessarily high, but in the regular construction of freight engines, where the boilers are new throughout, the space over the fire-box will be made smaller.

The closed cylinder *S* is attached to the back tube-sheet and extends over the whole length of the fire-box projecting out

* *Glaser's Annalen für Gewerbe und Bauwesen.*

through the back plate. In the attachment of the forward end of this cylinder, by means of the flanging, the original number of tubes is not materially lessened. It should be noted that in converting boilers of the present construction into those having the brick fire-boxes, it is not necessary to increase the heating surface of the tubes by an amount equal to that of the fire-box which is removed. It is possible to work with a considerably smaller heating surface without in any way diminishing the original efficiency of the boiler, as the experiments, which will be detailed later, have shown. In the case under consideration the reconstructed boiler had a total heating surface of only 1,141 sq. ft., while that of the original boiler was 1,335 sq. ft.

The cylinder *S* offers, as shown by fig. 2, a suitable support for both sides of the brick crown. At the outsides the arch of the crown has a footing on the top of the side walls. In order to obtain the most perfect combustion possible, there is a brick arch of proportional length, which extends over the forward half of the fire-box. On each side of the brick arch and close to the tube-sheet there are openings for sweeping out such accumulations of soot and unburned coal as may have collected upon it. It has also been demonstrated that such accumulations, both here and in the smoke-box, are exceedingly small.

In the construction of this fire-box a highly refractory material must be used, since the temperature stands at from 2,500° F. to 3,500° F. The ordinary so called Chamotte stone is not good enough for this work, and I have therefore used a fire-brick made out of a mixture of burned argillaceous schist and a platinum-bearing clay containing a little silicic acid, and where it is held in a combined form as perfectly as possible. According to results which have been obtained up to the present time, a fire-box built up in this manner can be counted upon to give about 12,500 miles of service. As shown by the engravings, the side walls are built of ordinary blocks with a slight groove; these walls run out to the outer shell of the fire-box, while between the latter and the alternate courses there is an air space of from 1 in. to 2 in. Other than this, there is almost no anchorage between the sheet and the walls. It has been shown that this arrangement makes an extraordinarily solid fire-box, and one which is not at all disturbed by the very considerable shocks to which it has been subjected, and one which is also guaranteed to be very effective against jets of hot water. The side walls as well as those at the front and back are attached to the outer shell by a channel iron ring. The opening for the fire-door is made in the back sheet by an angle iron ring to which a wrought iron ring is riveted. A similar and somewhat cone-shaped frame carries the fire-door, and is itself filled with a protective fire-brick.

As for the grates, which have an area, as given later on, of 16 sq. ft., it may be mentioned that they are of the rocking type, so arranged that the front end of one-half can be raised and lowered about 1¼ in. Thus, as shown in fig. 4, of the two grate-bars *E* and *C*, one is rigid and the second is fastened to the oscillating shaft *D*. This latter supports the movable bars, which can be easily moved up or down from the foot-plate by means of the levers *H* and *K*. In ordinary running the movable bars are kept flush with the rigid bars, as indicated by *Z*, fig. 2.

It will be readily understood that the formation of steam on the tube-sheet would be very great, and that in consequence thereof there would be a strong current of water flowing against it, hence it becomes necessary to take some precautions in order to prevent the formation of scale. For this purpose the plate *A B*, shown in figs. 1, 2 and 3, is used. This is fastened to the sheets of the shell by means of angle irons, and is bored with holes for the admission of the tubes. In this space, enclosed between the plate and the tube-sheet, there exists, in consequence of the temperature, which is considerably higher than in other portions of the water space, a rapid upward current, so that on the interior there is always a fresh stream of water flowing against the hot surfaces of the tube sheets and the back ends of the tubes; and, on the other hand, the finely divided particles of scale are carried up by the current and prevented from settling near the tube-sheet. It should be noted that the prevention of scale formation and the production of a rapid circulation is of especial service, as experience has shown in connection with the brick lined fire-boxes built by me for locomotive boilers between the years 1879 and 1886, for unless this is done the life of the tube-sheet will be very short. I am aware that a similar experience has obtained on the Hungarian State Railway, where it has also been shown that the life of the tubes will be shortened as well.

The results of practice, which have been obtained with the boiler built on the lines just enunciated, have shown a perfect freedom from the foregoing defects. It is, therefore, safe to say that the life of the tubes will henceforth be no shorter than in the ordinary type of locomotive, because even unskilful firing and a partial baring of the grates, admitting a great quantity of air, cannot cause a rapid or material cooling of the tube-sheet, since in the higher temperature of the sides of the fire-box there is an ample reservoir of heat to warm all the air by contact before it reaches the tubes. In order to give the products of combustion full opportunity to communicate their heat to the tubes on their way to the smoke-box, a deflector-plate *M N* is placed in the latter. This is pivoted at its upper edge *N*, and, when it is necessary to clean the tubes, can be easily turned up out of the way. Measurements in the smoke-box have shown that the temperature of the gases leaving the tubes is about the same at all points. This construction, which has such a wide application on American locomotives, can therefore be regarded as a very effective arrangement.

The cost of this new construction, if applied to a boiler previously built, is very considerably less than for a new fire-box of the ordinary construction. The latest figures show that 4,500 marks (about $1,125) was received for old material, while the new fire-box cost only 3,100 marks (about $775). For building an entirely new boiler with the brick fire-box having a capacity sufficient for the standard freight engine, the expense would be about 6,000 marks ($1,500), while the cost of a boiler of similar efficiency of ordinary construction would be about 11,000 marks ($2,750).

Working of Locomotive No. 834 with the Brick-lined Fire-Box.—First of all, a number of trials were made in order to obtain the necessary information regarding the handling of the fire. It appeared that this differed from that giving the best results with the ordinary fire box, in that it was unnecessary to maintain so deep a fire, since the grate area was proportionately smaller. In spite of this there was a very slight production of carbonic oxide, which, as is well known, causes a very marked lowering of the effectiveness of the fire.

A difficulty arose in the progress of these experiments in that the material originally used for the construction of the walls was found to be deficient in refractory powers. In consequence of this a molten clinker ran down from the crown and the arch, which clogged the grates, especially near the tube-sheet and the side walls. This difficulty has been removed, as I have already said, by the use of highly refractory materials.

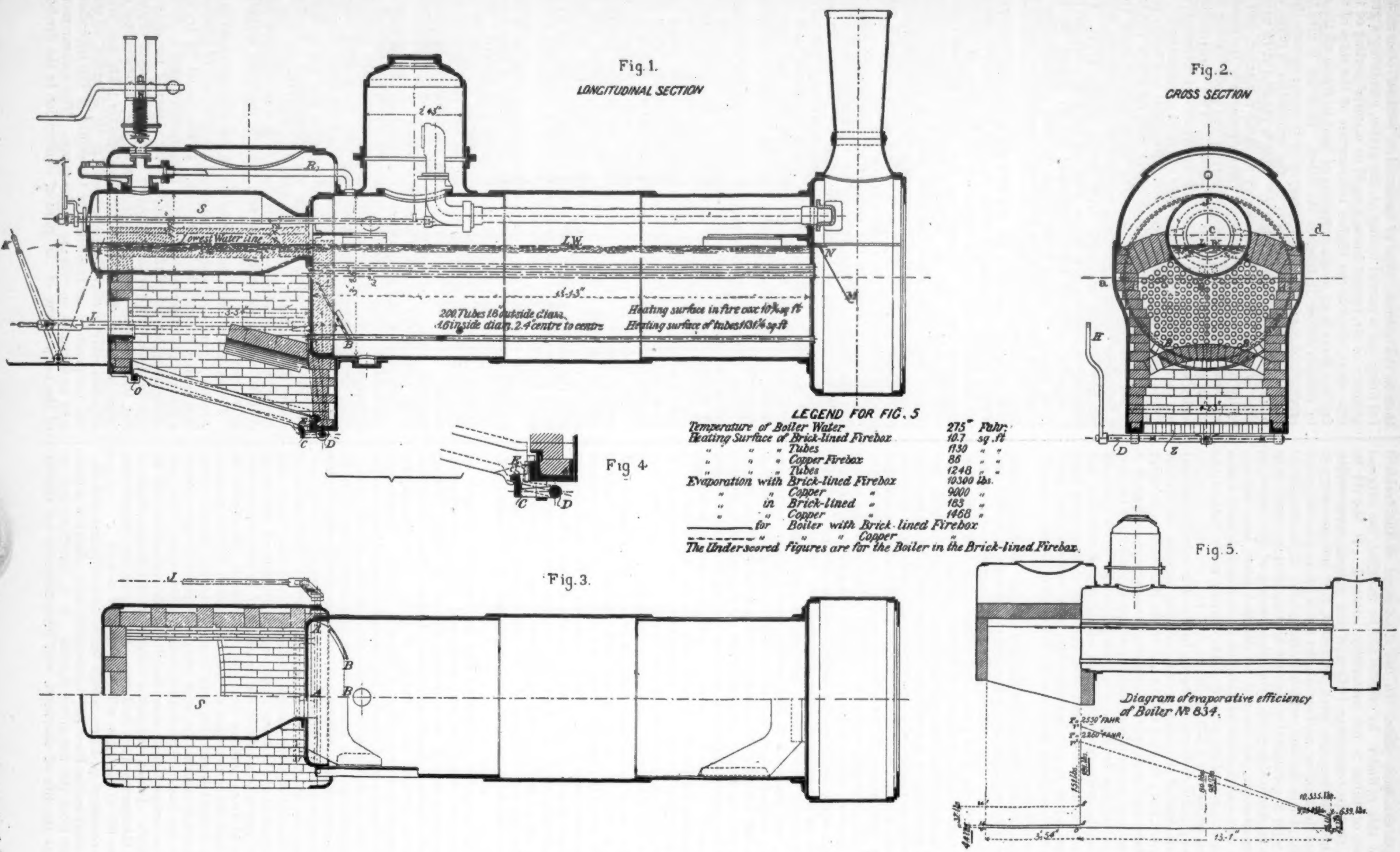
Then, in order to have a basis of comparison for efficiency, the engine was put upon a systematically laid out freight run of 80 miles on the line from Tempelhof to Bitterfeld, and on one of 73 miles from Tempelhof to Elsterwerda, working in both directions. Likewise trains were dispatched under the most disadvantageous conditions of the weather, when the work must be done in the teeth of a storm or in a fall of snow.

The weight of trains was therefore very frequently no greater than that given to the ordinary locomotives equipped with the original form of fire-box. The evaporation was so free on the heaviest upgrade, which was about 1 in 200, that with the normal load on this grade a speed of from 18½ miles to 22 miles per hour was maintained with a draft that rarely exceeded 2 in. in the water column.

In order to obtain the most reliable averages possible in our investigations as to the merits of the new boiler, a large number of trains loaded with perishable goods were hauled. The average efficiency was obtained by measuring the draft of the train by a Holtz apparatus fastened to the back end of the tender. The speed between stations was obtained by noting the total time, deducting two minutes for starting and stopping, and also by means of a speed recorder.

Furthermore, the evaporation at different speeds, as well as the vacuum in the smoke-box, was very carefully observed at different speeds. Water measurements were taken at every stop, and the waste water which was used for wetting down the coal, injecting into the smoke-box, and for other purposes was deducted. The evaporation obtained in this way is therefore only an approximation of the water evaporated. As close observation showed that comparatively high water was a rarity, it is evident that comparatively little was entrained, and that the results obtained were very close to the water actually evaporated.

It was also of great interest to obtain the most accurate data possible regarding the temperature of the products of combustion as they entered the smoke-box. It was found, by trying a great many different methods of measurement, that a quicksilver thermometer with its bulb in the center of the smoke-box gave the best results. Then by having a means of adjusting, the temperature at the upper as well as the lower row of tubes could be obtained. After the deflector-plate had been adjusted only a slight variation was to be observed, so that the temperature as measured at the center of the tube-sheet may be taken as an average of the whole. The measurement of the temperature of the gases of combustion in the fire-box



THE BORK LOCOMOTIVE BOILER WITH BRICK-LINED FIRE-BOX.

was made at the back end of the fire-box above the brick arch by means of a metallic pyrometer.

In order to insure the perfect combustion of the fuel and the complete convection of the heat produced, a large number of analyses of the gases as they entered the smoke-box were made. These analyses were made by means of the Orsat apparatus, and by taking the averages of a large number of examinations the amount of carbonic oxide and carbon dioxide was obtained. Samples were taken when the fire was burning normally with the fire-door closed.

In order to obtain the amount of convection to the fire-box casing, the temperature of this latter was obtained by a large number of observations made on the side walls as well as at the front and back. The thermometer was put in through the jacketing until the bulb was in contact with the plate. In like manner the temperature of the outer shell of the fire-box of the ordinary engines was obtained.

Experimental Investigations and the Results Derived Therefrom.—The efficiency of the locomotive, after the new design of boiler was placed upon it, was at least equal to that which it had originally. The machine was therefore not only up to the limit of its efficiency, but was capable of still further increase of work, in spite of the fact that the original boiler had 194 sq. ft. or about 17 per cent. more heating surface.

At a speed of from 15 to 19 miles per hour, with the steam cutting off in the cylinder at from one-third to one-quarter stroke, and a vacuum in the smoke-box of 2 in. of water column, the engine with the new construction developed about 450 H.P., while previously under exactly similar circumstances it had not been able, as a general rule, to develop more than 420 H.P. The number of loaded axles hauled could therefore be somewhat increased, as was shown by the tabulated results obtained by the maintenance of the normal steam pressure, the height of water in the boiler being held without any difficulty. The coal consumption was generally 10 to 25 per cent. less, as shown by the premium awards.

Now, from what has been just stated, and which has been established by carefully observed performances—namely, that the engine with the brick-lined fire-box has not only fully reached the original efficiency which it had, but has even exceeded it somewhat, so it is therefore especially important to establish by numerous experiments that the absorption of heat with the new construction is at least fully as perfect as that with boilers heretofore constructed with a copper fire-box. In order to have a definite understanding of the matter, it is necessary that we should take into consideration the course of events as they occur in the transference of the heat to the water of the boiler, and to determine how many heat units can be thus transferred to the water by the burning of 1 lb. of coal. The events as they occurred in the brick-lined fire-box are, that the total amount of heat developed passes into the products of combustion. If we deduct therefrom the very slight amount of heat which passes direct into the boiler, the heat contained in the products of combustion will then, for the most part, be transferred into the water of the boiler surrounding the tubes as the gases stream through these latter. The loss of the heat, which the gases still contained when they enter the smoke-box, is a matter of the utmost importance. It is carried out through the stack and serves to lower the evaporative efficiency. It is evident that this loss increases with the temperature of the gases in the smoke-box, and also increases with the quantity of air which must be brought into the fire-box in order to burn a pound of coal. Furthermore, observations must be made as to the loss of heat which occurs by convection and radiation through the walls of the fire-box. All other loss, such as radiation through the grates, loss of heat in the ashes, etc., can be considered to be the same in the new boiler as in the earlier ones, and should not be made the subject of observation, since the circumstances are the same and of equal magnitude in both cases. It is evident that in a comparison between the two types of boilers relatively to their efficiency as heat-absorbers, they must be the same if the temperature of the gases entering the smoke-boxes shall be the same, and if, furthermore, the radiation through the enclosing shells of the fire-box shall be the same, and finally, if the same quantity of air is used in burning the same quantity of coal.

If combustion is to be perfect, then the least possible amount of air must be admitted, the whole of the coal must be burned into carbonic acid, and no carbonic oxide must be developed.

By reference to the relative chemical equivalents, we find, therefore, that for 1 lb. of coal it is necessary to supply 2.67 lbs. of oxygen and 8.94 lbs. of nitrogen, so that the gases resulting from the perfect combustion of 1 lb. of coal is $1 + 2.67 = 3.67$ lbs. of CO_2 of carbonic acid and 8.94 lbs. of nitrogen, making a total of 12.6 lbs. In this case then 11.6 lbs. of air must be admitted in order to burn 1 lb. of coal. The volume of the gases resulting from this combustion will equal about 38 cub. ft. of carbonic acid gas CO_2 and 146 cub. ft. of nitrogen. Practically it is not possible to admit such a small quantity of air and cause all of the oxygen contained therein to be converted into carbonic acid gas. There must be many times the necessary quantity of air admitted if the formation of carbonic oxide is to be entirely avoided.

From the analyses of the gases of combustion taken from the locomotive with the brick-lined fire-box, it was shown that in the smoke-box, when the engine was working in its regular way, gases of combustion contained 12 per cent. of CO_2, 6 per cent. oxygen, and 82 per cent. nitrogen. It therefore appears that carbonic oxide was not present, and that the gases of combustion which resulted from the burning of 2.2 lbs. of coal contained 38 cub. ft. of carbonic oxide, 19 cub. ft. of oxygen, and 280 cub. ft. of nitrogen. The weight of this volume of gases was 3.67 lbs. of carbonic acid, 1.32 lbs. of oxygen, 15.4 lbs. of nitrogen, making a total of 20.9 lbs. of gas of combustion. Hence there was admitted $20.9 - 1 = 19.9$ lbs. of air, or $19.9 - 11.6 = 8.3$ lbs., or 71 per cent. more than the minimum volume which is absolutely necessary for complete combustion. In this weight of gas of 20.9 lbs. the total heat developed by 1 lb. of coal is contained. Hence, the heat effect produced by the use of this coal was 12,625 heat units per pound. Since the temperature of the gases in the smoke-box under average conditions was 525° F., it is evident that the loss of heat which passes out through the stack with the gases, and which cannot be made available for evaporative purposes is equal to $20.9 \times 525 \times .23 = 2,524$ heat units, or taking a percentage of the total heat developed of 12,625 heat units, we have a loss in round numbers of about 20 per cent. Therefore from the combustion of 1 lb. of coal we have $12,625 - 2,524 = 10,101$ heat units, which was transferred to the water of the boiler. Equalizing this with the heat absorptions in boilers with the ordinary fire-box we come to the next result. A series of analyses, made with the standard freight locomotive, showed that when the combustion of the fuel was perfect the volume of the gases averaged about 9 per cent. carbonic acid, 8.5 per cent oxygen and 82.5 per cent. nitrogen, making a calculation similar to the one just given: we find that the gases resulting from the combustion of 1 lb. of coal consists of 3.67 lbs. of carbonic acid, 2.5 lbs. of oxygen and 21.5 lbs. of nitrogen, giving a total weight of 27.6 lbs., so that it is evident that 26.6 lbs. of air was admitted for each pound of coal. It seems from this, then, that, with the ordinary type of locomotive fire-box, in order that a perfect combustion may be obtained, a considerably greater excess of air must be admitted than the minimum, which is absolutely necessary, and the excess per pound of coal is equal to $26.6 - 11.6 = 15$ lbs., or 2.3 times the weight of air absolutely required. On the other hand, the new construction only needs $26.6 - 19.9 = 6.7$ lbs. of air more than is absolutely used.

In consequence of this great excess of air there is a considerably greater loss with the escaping gases than occurs with the brick-lined fire-box, since the temperature of these gases is not materially lower than in the brick-lined box. Furthermore, investigations with the standard freight engines have shown that the smoke-box temperature is practically the same as in that of the boiler with the brick-lined fire-box. The observations show a variation between 500° F. and 575° F., so that it would not be far out of the way if we should say that an average of the whole was at 525° F. Under these circumstances the loss of heat with the ordinary fire-box can be calculated to be about $27.6 \times 525 \times .23 = 3,333$ heat units, or in round numbers about 26 per cent. of the heat developed by 1 lb. of coal. Therefore for this method of combustion 1 lb. of coal would give up only $12,625 - 3,333 = 9,292$ heat units to the water of the boiler, while the absorption with the brick-lined fire-box under the same conditions would be 10,101 heat units. Therefore the boiler with the brick-lined box shows a saving of about 8 per cent. of the heat developed over that of the ordinary fire-box.

It may appear questionable, however, whether this improvement in the absorbing qualities may not be lessened by the radiation of heat through the walls of the fire-box. In order to obtain definite information in regard to this subject, similar temperature measurements were made with the boiler having the new fire-box and a boiler with a copper fire-box. The following are the results obtained from this examination:

Ordinary Locomotive No. 525.	New Locomotive No. 834.
Side sheet, 206° F.	Side walls, 199° F.
Back sheet, 156° F.	Back walls, 194° F.
Front sheet, 156° F.	Front wall, 203° F.

Outside air, 50° F.

From the slight difference in these figures it will be seen that there will be relatively a very slight difference in the loss of heat. It may be assumed that the radiation of an iron sheet into the surrounding atmosphere per square foot per hour for 1° difference in temperature will be about 2.86 heat units.

Hence, taking the measurements of the two fire boxes into consideration, it will be found that the brick-lined box will radiate about 1,700 heat units per hour more than that with the ordinary construction. This loss will be supplied by the consumption of about .18 lb. of coal per hour, and therefore is of so slight a value as to deserve no consideration whatever.

It is also evident that there will be a loss of heat in proportion to the weight, which is absorbed in heating the brick work of the fire-box up to the working temperature; but it must also be remembered that this heat was formerly wasted to a great extent, and in this case it is given back to the water of the boiler when the engine is standing still. But this has relatively no importance in the necessary heat production during the daily work. The temperature on the fire side of the brick wall will be about 2,550° F., while on the other side it will be about 400° F., so that we may consider that the brick work has an average temperature of 1,475° F. The total weight of the brick work may be placed at 2,200 lbs., and taking the specific heat of the stone at .2, the total heat contained in the brick work will be about $2,200 \times 1,475 \times .2 = 649,000$ heat units, which is equivalent to a combustion of a trifle more than 50 lbs. of coal. This insignificant consumption need not be taken into consideration, as it is well known that, for heating up the ordinary locomotive boiler, there is required on an average about 300 lbs. of coal.

From the foregoing data a twofold conclusion can be drawn—namely, that with an equal consumption of coal the boiler with the new fire-box has a somewhat higher efficiency in its absorption of heat and a greater evaporative efficiency, in spite of the fact that it has a smaller heating surface than the ordinary type of boiler.

It is of interest, therefore, to obtain a clear idea of the evaporative efficiency of the heating surface in the boilers with the new fire box, on the basis of the results obtained, and then to put it in comparison with that of the ordinary type of boiler.

The evaporative efficiency of the heating surface per unit of time is dependent, on the one hand, on the size, and, on the other, on the difference in temperature which exists on the two sides of such surfaces. This difference of temperature has undoubtedly its highest value in the fire-box, and falls gradually down from that point to the smoke-box. On their entrance into the tubes the products of combustion have a temperature of about 2,550°, while on their exit into the smoke-box under normal conditions of working, the temperature is not above 525°. The water in the boiler is under a pressure of about 150 lbs. to the square inch, and has a temperature of approximately 342° F. The differences, therefore, in temperature are $2,550 - 342 = 2,208$ at the fire-box end of the tubes. while it is only $525 - 342 = 183°$ F. at the smoke-box end. The total evaporation per hour has a normal efficiency with a vacuum of 2 in. of the water column of 10,518 lbs. One square foot of heating surface therefore corresponds to an average evaporation of $\frac{10,518 \text{ lbs.}}{1,141 \text{ sq. ft.}} = 9.21$ lbs. per hour.

If we investigate the amount of heat taken up by the tubes and indicate the evaporation in the fire-box and on the smoke-box tube-sheet per hour, and indicate the efficiency of 1 sq. ft. of heating surface in these two points by x and y, we have the proportion $x : y = 2,208:212$. From this we may deduce the fact that, at the fire-box end, evaporation is equal to 1.67 lbs. per square foot. It may be taken for granted that the evaporation throughout the boiler per square foot of heating surface is very nearly the same as that of 1 sq. ft. of the heating surface of the tubes midway between the fire-box and the smoke-box. Out of the 10,518 lbs. of water evaporated, we have about 183 lbs. in round number evaporated in the fire-box, so that the $10,518 - 183$ lbs. $= 10,335$ lbs., which must be evaporated throughout the length of the tubes. Taking the heating surface of the tubes into consideration, we find that we have an evaporation of about .89 lb. per hour.

Furthermore, there is a cooling which occurs throughout the boiler, so that the temperature of the gases which enter the tubes at 2,550 F. likewise falls away, so that we may consider the evaporation immediately at the fire-box end of the tubes to be 1.65 lbs., and at the smoke-box end as .14 lbs. per square foot per hour. If we take this evaporation as the ordinates at the end of the line $o\ p$ (fig. 5), whose length corresponds to that of the boiler, and connect the points q and r, then all points in the line $r\ q$ lie in ordinates representing the evaporation at different portions of the length of the tube along the boiler. If we divide the line $o\ p$ into 1,130 equal parts and erect ordinates at the points of division, then the surfaces which are included between the neighboring ordinates and the portions of the lines $o\ p$ and $r\ q$ will represent the evaporation per square foot per hour. The surface $o\ p\ q\ r$ has a total evaporative efficiency of 10,335 lbs. per hour. The evaporation of the boiler which extends over the brick portion over the fire-box in the brick-lined fire-box, will be represented by the rectangle $o\ v\ u\ s$ included by the abscissas and ordinates. The height $o\ s$ of this rectangle shows that the product of the figures denoting the area must be the same and give the same results of evaporation as in the ordinary fire-box. The surface $b\ o\ p\ q\ r\ s\ u$ then shows the evaporative efficiency of the total heating surface, as well as that which obtains in the different portions of the boiler. In like manner the surface $b\ o\ p\ q\ r^1\ s^1\ u^1$ gives the evaporation of the boiler with the original form of fire-box.

The heating surface in the fire-box was 86 sq. ft., and in the tubes 1,110 sq. ft. The evaporation in the fire-box per square foot per hour can be taken to be the same throughout its whole area, and evaporation then becomes 143.92 lbs.

The figures obtained from this calculation show the evaporative efficiency without any further trouble, and it can be readily seen that the boiler with the new fire-box, in spite of its smaller heating surface, can transfer an equal amount of heat to the water per unit of time, as the ordinary fire-box. These facts are clearly explained when we remember that with the brick-lined fire box the gases enter the tubes at a considerably higher temperature than they do where the ordinary fire-box is used, and evaporation per unit of heating surface is correspondingly increased.

The most important point, however, is that the smaller heating surface, in spite of the higher temperature of the entering gases, is so effective that the latter are cooled down to a point as low as they are with the ordinary construction.

The efficiency of a locomotive therefore should not be based, as heretofore, upon the heating surface, but rather upon the amount of heat which can be developed and absorbed in a unit of time. The amount of heating surface, therefore, should only enter into the consideration so far that it shall be sufficient to lower the temperature of the gases under normal conditions to 575° F. The further lowering of this limit of temperature by increasing the heating surface gives no real advantage in actual effectiveness. Suppose that the tubes of engine 834 were lengthened 15.7 in., whereby the heating surface would be increased about 10 per cent., then by the graphic method of representation which we have used, the increase of evaporation would only amount to about 77 lbs of water, or .75 per cent. of the total evaporation obtained. This increase of evaporation is a mere bagatelle when compared with the increased first cost and expense of maintenance with tubes having 107.6 sq. ft. less of heating surface.

Advantages of the New Type of Construction.—Aside from the improved steaming qualities, whereby a lower consumption of coal produced the same efficiency, there are two facts which seem to particularly warrant the introduction of this new type of boiler, to wit:

1. A very greatly reduced outlay in first cost, and
2. Possibility of an important increase of steam pressure, and therefore an increase of efficiency without a corresponding increase in the weight of the locomotive.

The author then goes on to make a careful comparison between the expense of construction and maintenance of the copper fire-box and the brick-lined fire-box of this new construction. As copper fire-boxes are unknown in American practice at the present time, these figures do not show what the relative expense would be between the brick-lined box and the steel box used in this country; but his conclusions, relative to the copper fire-box, are that there is a saving of maintenance of about 29 per cent.

The second important feature of the new fire-box—namely, that the steam pressure can be considerably higher than in that of the ordinary boiler, comes from the fact that the boiler being cylindrical in form, the only exception to perfect stability is at the points where the tubes enter and leave. In the ordinary fire-boxes which have thus far been made, the upper limit of pressure for locomotive boilers may be placed at 180 lbs. per square inch, and already at this pressure the maintenance of stay-bolts has been found to be very difficult, and accidents are no longer rare where the sheet has been stripped off the thread. With this new construction a pressure of 240 lbs. per square inch can be used without increasing the thickness of the metal heretofore employed, and it is within the possibilities of building a new boiler and using an increased thickness of metal that will readily sustain a pressure of 300 lbs. per square inch. But even with an elevation of pressure of from 150 lbs. to 240 lbs. per square inch there will be a very noticeable increase in efficiency, as will be seen by making a comparison of the work of these two pressures. Furthermore, the throwing of sparks is very much less with the brick-lined fire-box than with the fire-box of ordinary type, because the incandescent particles of coal will be completely burned before leaving the tubes, when they are subjected to the influence of the high temperature of the gases of combustion and the hot walls of the fire-box.

THE STEERING OF BALLOONS.*

By Rudolphe Soreau.

II.—ATTEMPTS AT STEERING.

I now beg to call your attention to a brief examination of those attempts at steering which merit attention, and in which I shall not seek to enter into details, but shall show in what way and to what extent the conditions laid down in the preceding section have been realized, following, as far as possible, the order given in the table.

General Meusnier.—The true progenitor of dirigable balloons is General Meusnier, of whom Monge has said: "He possesses the most extraordinary intelligence that I have ever come in contact with." In a series of papers, written in 1783, Meusnier laid down a project for a dirigable balloon, which did not receive in those troublous times the slightest approach to a practical application; it would, furthermore, have been difficult to construct this gigantic balloon, which was a sort of egg, with a capacity of 7,063,200 cub. ft.

There were three peculiarities characterizing this project. First, the propeller form of turning wings, which constituted a true helix, so that, according to the remark of Colonel Laussedat, Meusnier conceived the idea of using the helix for navigation long before Sauvage. Second, the ellipsoidal form of the balloon. Third, the presence inside the envelope of a pocket in which could be compressed the atmospheric air. This kind of natatorial vessel having for its object the realization of the ascensional and descensional movement without loss of ballast or gas. Meusnier counted on finding an aerial current flowing almost exactly in the direction which he desired to travel, and expected to pass to another current in order to correct the variation due to the first, and thus one after another to follow by a series of zigzags, the route over which he desired to pass. He did not attack the problem from the front; and the propeller, which was driven by men, was to play the rôle of an elevator and depressor.

Henri Giffard.—The first rational experiment was made about 50 years after the death of Meusnier. It was made by a man whose eulogy it is superfluous to pronounce, and whose mind, at the same time inventive and bold, was attracted by the grandeur of the problem.

The balloon which Henri Giffard constructed in 1852 (fig. 4), by the aid of Messrs. David and Sciama, Engineers of the School of Arts and Manufacturing, fulfilled the following conditions:

1. Thoroughly understanding the impotence of a propeller driven by men, Giffard resolved to use the steam-engine, then in its glory. The installation of a motor apparatus below a reservoir containing 92,290 cub. ft. of illuminating gas constituted a danger which did not deter him. He contented himself with placing the fire-box inside the boiler with a double envelope, and causing the gas to escape by a descending stack into which the steam escaped with all its expansive force as it left the cylinder; thanks to this energetic cause, the gases of combustion, already cooled in their passage through the envelope, were drawn into the stack, where the expansion of the steam lowered their temperature still further and killed all the sparks which they might contain, and threw them rapidly toward the back, so as to aid him in the movement of propulsion. The engine was a vertical cylinder machine; it already fulfilled in advance a portion of the progress of 10 years, from 1851 to 1861, which was brought about by this genius of an inventor in his steam-engines. Its power was 3 H.P. and its weight 330 lbs. with the empty boiler; the fuel and water doubled the weight. The shaft of the motor ran, at the rate of 110 revolutions per minute, a three-armed screw 11 ft. 1.9 in. in diameter.

2. The balloon was spindle-shaped, with sharp points which certainly offered a more logical form than that of the ellipsoid. It measured 144 ft. 4 in. from point to point. The elongation —that is to say, the ratio of the length to the maximum height —was 3.6 to 1.

3. The net embraced almost the whole upper portion, even to the points; a little below the center the meshes expanded out into diamond shapes in order to make a better distribution of pressures on the envelope. These meshes formed the direct means of suspension of a long horizontal frame from which, at a distance of 65 ft. 7 in., the basket was suspended. The back end of the suspended portion served as a post for attaching the rudder. The valve at the top of the balloon could be opened by a cord, which passed through a shaft situated in the same vertical plane.

"I started alone from the Hippodrome," writes Giffard. "The wind blew with great violence. I did not dream, for an instant, of struggling directly against the wind; the strength of my engine would not have permitted it. That was acknowledged in advance and demonstrated by calculation, but I executed with great success different movements in a circle and with a lateral deviation. The action of the rudder quickly made itself felt, and scarcely had I pulled lightly on one of the two tiller ropes than I immediately saw the horizon turning about me. Nevertheless, as night approached I occupied myself with regaining the earth, and this I effected very fortunately in Elancourt, near Trapp."

After this happy experience Giffard sought to make a new step in advance. He constructed a balloon with a capacity of 112,995 cub. ft. and a length of 229 ft. 8 in., corresponding to an elongation of 7 to 1, which was practically about double the preceding one, and is shown in fig. 5. The beam was replaced by a wooden cross-piece placed along the upper meridian, the shape of which it followed, and does not seem to me to constitute any improvement over the original design. Finally, the motor and the rudder were subjected to important modifications. Yet Giffard did not see that the considerable elongation which he had adopted required special precautions. Thus, with the test which was made in 1855, accompanied by Mr. Gabriel Yon, in a wind with a velocity of 13 ft. per second, the results were less fortunate than the first; it lacked but very little in ending in a catastrophe. On rising the balloon turned about on itself, escaped from the net, and after a new ascension fell, cut into two pieces. The shock was produced by a sudden variation of the wind of several meters per second.

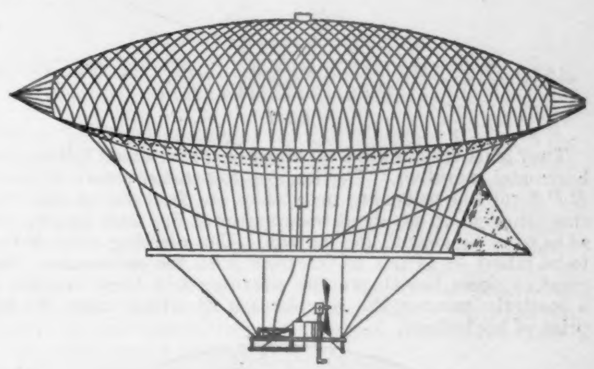


Fig. 4.

From what I have said regarding the conditions which a dirigable balloon must fulfil, it can be seen that the two great defects of the Giffard balloons were in not realizing them, either in permanence of form or rigidity of construction. Either one of these defects would have prevented success. As accessory defects, I will cite the following: Silk used in the inflated portion diminished to a great extent the advantages of the elongation from the standpoint of resistance; the consumption of water and fuel caused a continual lightening, which was not compensated for by the inevitable loss of gas; finally, the use of illuminating gas was not a fortunate one, and the difficulties of the problem are so great that no one should hesitate to inflate with hydrogen.

However that may be, Giffard, who counted on building the first aerial locomotive, will at least have had the glory of building and showing the first balloon which could be classified among the dirigable balloons. He conceived the ambitious project of a gigantic balloon of 1,765,773 cub. ft. capacity; the motor was to have had two boilers, one burning the gas of the balloon and the other petroleum. The million francs intended for this experiment were ready; the plans were prepared when Giffard, struck down by *cecité*, was compelled to give up work. Before dying the eminent engineer still desired to serve science by allowing it to profit by the great fortune which a life full of labor had given him.

Dupuy de Lome.—Giffard's works did not change public opinion, which continued, except on rare occasions, to consider the steering of balloons as a kind of Utopian dream. Such was the official opinion when on October 10, 1870, in the full session of the Academy of Science, a prominent man, Dupuy de Lome, affirmed, with considerable conviction, that he had taken upon himself to build a dirigable balloon and to establish thereby, in spite of the circle of iron which strangled Paris, the reciprocity of relations between France and its capital. Can we doubt the success of the engineer who made the first armor-plate, and who passed in his own right as one

* *Mémoires de la Société des Ingénieurs Civils.*

of the illustrious men of the century? The credit of 40,000 francs was placed at his disposal, but the disorganization of industrial enterprises, the severity of the winter, the lack of resources, rendered the construction very slow, and the dirigable was ready only a few days before the capitulation. It was characterized by the following arrangements, as shown by fig. 6:

1. The propeller was a two-armed screw provided with a crab turned by eight men. It was 19 ft. 8 in. in diameter.

2. The balloon, which had a capacity of 127,137.6 cub. ft., had a form similar to that of Giffard's, but its elongation was only $2\frac{1}{4}$ to 1. Its length was 118 ft. 1.3 in.

3. The rigidity of construction was obtained very simply by attaching a point P of the car to the two points A and B of the balloon (fig. 7), so that the vertical $P\,V$ was always included inside, the angle $A\,P\,B$ when the system assumed an inclined position for any cause whatever. Under these conditions the weight of the car stretched the two chords, and the construction possessed the same rigidity as though it were formed of metallic bars, solidly riveting the connected points together. The exterior connection points $A\,P$, $B\,Q$ constituted the carrying net.

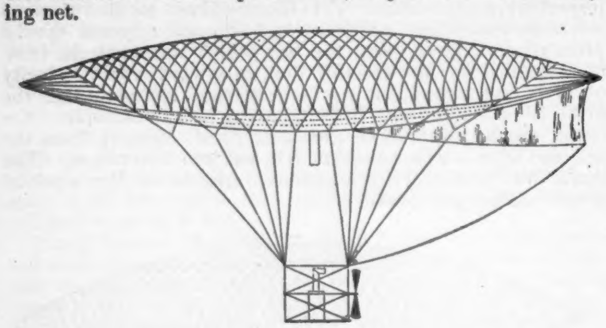


FIG. 5.

They start from a kind of gland or circle which follows the horizontal meridian. The interior suspension points $A\,Q$ and $B\,P$ form the balancing net; they are fastened to a second ring situated up at about one-quarter of the total height, and so as to be tangent to the balloon. The crossing point M had to be raised so as not to interfere with the aeronauts. The great engineer has shown the advantages of these two ties in a masterly manner, the combination of which bears the imprint of his balloon.

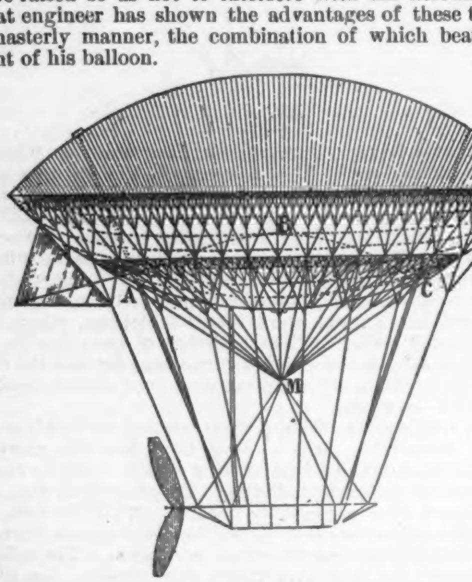


FIG. 6.

4. Dupuy de Lome, in reinventing the air balloon of Meusnier, whose memoirs were forgotten in the Archives of the School of Metz, divided the balloon into two compartments by means of a diaphragm, $A\,B\,C$, which was applied exactly to the lower part of the dirigable when it was completely inflated. To insure invariability of form, it was sufficient to inflate with ordinary air by means of a blower delivering into a pipe which connected the balloon with the car. If the air which was blown in was too great in quantity, it escaped by the safety-valve, located at the lower part of the balloon, before having acquired a pressure sufficient to drive out the hydrogen by the valves which are to be seen at the right and left of the balloon. It was to these valves that chords passed which served to manipulate the two hydrogen valves of the balloon. Simple calculations determined the dimensions which it was necessary to give to the balloon in order that the dirigable, after having reached a predetermined elevation, could be maintained completely inflated up to the time of its landing.

§ 5. Finally, the resistance to advancement had been diminished by the substitution, for the net, of a housing of cloth to which the balancing chords were fastened, and by the adoption of a long car terminated by a prow and a poop covered with silk.

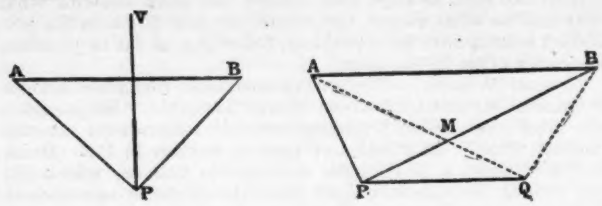


FIG. 7.

This balloon was very carefully designed from the standpoint of stability, but presents the capital defect of having a motive force absolutely insufficient to its needs. Dupuy de Lome understood this. "If it were possible," he writes, "to approach the dangers which an engine having a fire connected with it brings to the hydrogen-inflated balloon, it would be very easy to make an engine of 8 H. P. with the weight of seven men, which would very much diminish the weight of the equipage. The working motor would thus weigh about 490 lbs. The fuel and the water for operating the boiler could be used instead of the ballast, which is usually thrown out. We would thus obtain an apparatus capable not only of deviating at a considerable angle with ordinary winds, but even of following any route relative to the earth which might be desired." But we can charge against Dupuy de Lome the slight elongation which he gave to his balloon, while Giffard did not fail to give to his balloon the elongation of 7 to 1 in 1855, and that, too, without special precautions. Dupuy de Lome, with a balloon which was remarkably rigid, contented himself with an elongation of $2\frac{1}{4}$ to 1. Doubling this elongation, coupled to a motor of 8 H.P., would certainly have given very fine results. I may add that the balloon was not made, as we have said, for they understood very well that it would be impossible to avoid the use of the safety hydrogen valves of the balloon. The sides of the balloon had not been designed with a view of supporting a very great pressure, and the lower valve was regulated so as to allow air to escape as soon as its pressure exceeded that of the atmosphere.

The trial was made at Vincennes at the beginning of 1872; the inventor was accompanied by Mr. Zede, Engineer of Naval Construction, and Mr. Yon. In spite of a wind of 39 ft. per second speed and some accidents on the way, they obtained a deviation of 12°. The anemometer, which was immovable as long as the screw was standing still, turned as soon as the latter was started. The stability was perfect, according to the report of Dupuy de Lome. The car experienced no oscillation under the action of eight men working at the crab driving the screw, and they could easily have carried several persons more on either hand, or at front and back, without perceiving any movement whatever. The floor of a room could not have been more steady or level. Evidently the center of gravity in rising had a slight change along the vertical of the whole system, including the balloon and the car; but it was impossible to perceive any movement of the car relatively to the balloon, analogous to the oscillations of a floating boat, where the attachments and furniture are apt to be thrown about. Although Dupuy de Lome was not able to move against the wind on account of the insufficiency of his motor, his work resulted in the following expression of a committee appointed to be present at his trial: "It serves as a starting-point for the question which has been kept in a vague condition up to the present time, and of also serving as a necessary point of departure for all who wish to continue in this direction."

Mr. Tissandier.—It would seem that with Dupuy de Lome the aeronaut had said his last word, but a pupil of Giffard, who was an heir at the same time of the energy of his master, resolved to undertake new trials with a machine from which all sorts of marvels were expected—namely, the electric motor. It is evident, furthermore, that the dynamo which works without fire and without any variation in weight is not without its advantages from the aeronautic point of view.

The characteristics of the balloon which Mr. Gaston Tissandier constructed, with the assistance of his brother Albert, were as follows (fig. 8):

1. The dynamo was of the Siemens type. It was driven with a battery of the bichromate of soda very ingeniously arranged, so as to reduce the weight and obtain the greatest possible effect. The motor weighed 121 lbs. and the cells 496 lbs., and they contained liquid enough to work for two hours and a half. They were thus enabled to obtain $1\frac{1}{4}$ H.P. on the shaft of the machine, which put the average weight per horse power per hour, during the time that it lasted, a little more than 330.6 lbs. The screw had two arms, and was 9 ft. 1 in. in diameter; it was only controlled in its movements to a variation of $\frac{1}{10}$. This was one of the disadvantages inherent in the motor itself.

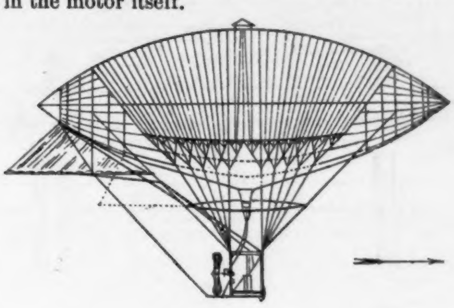


FIG. 8.

2. The balloon was spindle-shaped and had a capacity of 35,316 cub. ft., with a length of 91 ft. 4.4 in., and an elongation of 3 to 1; it was provided with an automatic valve at the bottom.

3. It was covered with a housing terminating in shafts of flexible wood, from which the suspension cords started. These latter were fastened by a crown in the crib, having for its object that of distributing the traction equally. This arrangement certainly does not give an absolutely equal distribution of the strains; I nevertheless feel that there was a certain efficacy about it.

The great defect with Messrs. Tissandier is that they did not profit by the works of Dupuy de Lome to insure the rigidity of suspension and the invariability of shape. Finally, they did not pay any more attention than their predecessors had done to maintaining the balloon absolutely in a horizontal plane. It is true, that with the electric motor they did not have, as Giffard did, the loss of ballast, which was due to the consumption of water and fuel; but this cause of instability is unfortunately not the only one.

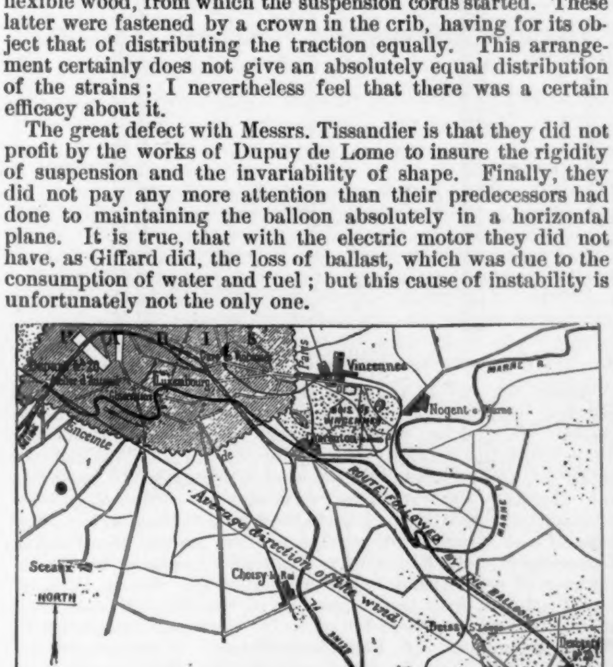


FIG. 9.

At the ascension of the balloon in 1883 the two brothers went up together, and made a good showing. Starting from the earth in a calm, they went up to an altitude of 1,640 ft. As generally happens up there, a wind of 10 ft. per second velocity was encountered, against which they could make no headway. Thus they stopped for some seconds above the Bois de Bologne, but they were troubled by giratory movements which increased in velocity as they sought to work against the current. The aeronauts, therefore, concluded that the rudder was not sufficiently efficacious.

At the ascension which was made in 1884 the motor developed 1.5 H.P., and the rudder, which was of larger dimensions, was placed at the back end, so that it extended out beyond the poop. The triangular portion next to the balloon formed a sort of immovable transom; the back part was moved by means of two lines passing over pulleys. The wind had a velocity of about 10 ft. per second, and the speed of the balloon was about 13 ft. per second. After having practically followed the line of the wind, during which the movements of the rudder turned them aside a little, the balloon, describing a semi-circumference, found itself with the wind ahead, and was navigated in this way for about 10 minutes directly above Grenelle. It repeated with the same success the same experiment above the observatory. Finally, before coming down, the wind having greatly diminished its velocity, they could go up against the current with great facility. "If we had had an hour before us," writes G. Tissandier, "it would not have been impossible for us to have come back to Paris."

Thus in three attempts, and during some minutes each time, the Tissandier brothers have been conquerors of the elements. It was a fine result, if we consider the difficulties which were met in this undertaking. The original construction had a volume of about 105,000 cub. ft., and cost about 200,000 francs. M. Tissandier made an appeal to the public and to scientific societies, but they scarcely obtained 4,000 francs. It is a sign of the times, which shows in what disfavor experiments with balloons are regarded. Left to their own resources, they were compelled to reduce the volume of the balloon to 35,316 cub. ft. M. G. Tissandier obviated a part of the disadvantages which the reduced volume caused them, by discovering a means of preparing very pure hydrogen, which possessed the remarkable ascensional force of .12 lbs. per cub. ft.

Although the trip, which was otherwise conclusive, had been made at Chalais before the ascension of 1884, others will not forget the grandeur of the effort made by M. Tissandier, and their absolute disinterestedness. Patriotic promoters of military aeronautics in 1870, these two men gained the recognition of their country.

(TO BE CONCLUDED.)

TESTS OF METALLIC TIES ON THE BELGIAN STATE RAILWAYS.

SINCE the establishment of the Belgian State Railways the management have been interested and engaged in the solution of the question of metallic supports for rails. Previous to the year 1846 there were three systems of metallic ties already in existence on the line between Brussels and Antwerp—namely, the Poncelet, the Gobert and the Marshal systems. None of them gave satisfactory results. In 1853 the management of the Belgian State Railway laid 5,000 ties of the Greaves & Barlow system, but the results obtained both in regard to the stability and the maintenance of the track were not as favorable as might have been desired.

In 1867 a special commission was appointed for the purpose of examining the different types of metallic track fastenings which were being exploited or experimented with at this time, and commissioners were sent by the government into France and Holland. Their attention was called to the Vautherin ties, to those of the Societé de Couillet and to those of Messrs. Le Grand and Salkin, and they proposed that the management make a trial of these on the tracks of the Belgian State Road. Before adopting this suggestion the management sent the same commission into France the following year for the purpose of having them visit the tracks and make a report on the question, whether those which had been cited were giving the same satisfaction to the engineers. The reports which were received at this time were less favorable. In spite of this quite a large number of Vautherin ties were laid in 1868. The results were very unsatisfactory. After an average of about six years they were removed from the track in order to avoid compromising the safety of the traffic. They had been covered with a thick layer of rust and had lost from 4.4 to 6.6 lbs. of weight, and a large number were cracked beneath the rail. The reason for this breakage was evidently due to the fact that these ties did not have a sufficient moment of resistance to withstand the deflective strains, which the passage of heavy freight trains put upon them, composed, as they are in Belgium, of 60 cars, hauled by powerful locomotives, especially upon certain sections of the line, as in the mountain passes of the province of Luxembourg, where the grades are as high as 1.8 per cent.

While these tests of the Vautherin ties were being carried on in 1869, the management also made some tests of the Le Grand and Salkin ties, which were condemned in 1873 on account of the bad results which they gave.

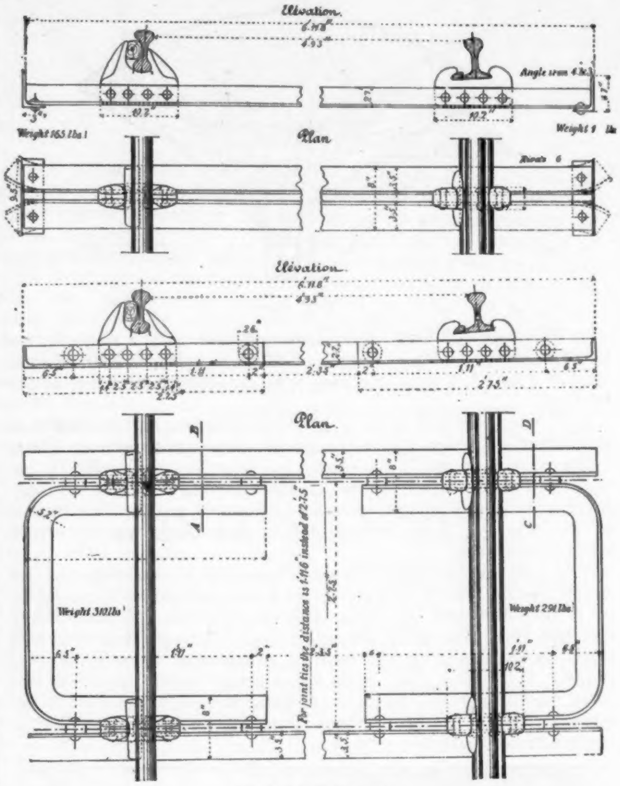
Between the years 1872 and 1879 the management made successive examinations into the designs of Hauwaert and Cabuy, of Kirsch, of Greef, of Potel, of Breten and of Wood, but did not see fit to make actual tests of any of them.

Another trial of an entirely metallic track was made in 1871 with the ties of Soignies de Schaerbeck, a new design, but containing nothing valuable, for these ties weighed 81.6 lbs., and were used under a strain of 106,618.5 lbs. per sq. in. They were only in existence one year. During the years 1878

and 1879 the management made some very extensive tests of the Hilf stringer for track, from which they expected good results. But here again, in spite of the very great care which was taken in laying the track and in the choice of ballast, which was of broken stone, gravel, and cinders, with the exclusion of all schistose matter, all broken so as to pass through rings 2.4 in. in diameter, they were not long in seeing that a favorable comparison could not yet be made with tracks laid on creosoted ties, either with reference to firmness of the track or expense of maintenance.

It was stated that the Hilf ties, which rested at their extremities upon metallic ties of the same transverse section as the stringers, with a single stay at the center of the length of the rail, did not guarantee that the lines of rails could be maintained in alignment. The chairs which held the rails to the stringers were not strong enough to resist the lateral thrust, due to the centrifugal force arising from the passage of trains over curves, and they were pushed to one side, working their attachments in such a way as to render them liable to cause serious accidents, especially derailments. Furthermore, it was also stated that under the disturbing action of the side lash of the trains, especially with locomotives having outside cylinders, the two lines of rails were given such a sinuous position, and it was increased by the passage of heavily loaded trains running under anything like express speed. The Hilf system of track, therefore, required for its maintenance very much more work, so that it was necessary to increase the size of the gangs of track layers and navvies. We may also add, in order to be exact, that the greater or less deformations, which were also produced in the vertical, were without doubt the cause of the great separation of the supports of the stringers; a circumstance as unfavorable as the preceding one to the preservation of the rolling stock, and to the security of the passage of the trains. The management of the State Railways after this new unfortunate experience, which was especially disappointing on account of the hopes with which they had entered into these tests, nevertheless did not immediately remove the Hilf stringers from their tracks. It attempted to remedy the matter by supporting the stringers at intermediate points between the supports, by putting in a third tie at the center of their length, and by further tying together two lines of rails with two stays instead of one. This was done on the line between Namur and Arlon, which is traversed by international express trains running between Libramont and Marbehan. The deformations, which have been indicated above, were diminished, but it was impossible to do away with them entirely. The notes in the memorandum and field books of the track department were always filled with fresh memoranda of the maintenance of this Hilf track, and were always greater in number than those relating to the standard track laid with Vignole rails upon oak ties of half-round form, with a height of 5.1 in. on a diameter of 10.2 in. and impregnated with creosote; until it was finally decided by the management of the Belgian State Railways, that they would remove the Hilf stringers from the main lines and lay them on the branch lines and switches at stations; or, in other words, on side tracks for standing trains and also on service tracks for furnaces, etc.

At the end of 1879 and in 1880 the management of the State Railways made a trial on a small scale of the Serres and Battig ties, between Buysinghen and Hal, on a high-speed line from Brussels to Mons; and at Angleur they tested some Helsen ties designed by the director of the Tardy & Beneeh Company, at Savogne, but, as happened with the others, the results were not very satisfactory. The average life of these ties was but a trifle over three years. In 1883 the management ordered its chief engineer to make a careful examination into the tracks and works laid under the Harrman system, which were of the stringer and cross-tie type, but the recent failure of the Hilf track prevented them from risking a test of a system of stringers. It did not consider it desirable to make a test of these ties on account of the complication of construction, which was considerably greater than that of the Vautherin system. It also refused to make any other experiments with the stringers and ties offered by Messrs. Caramin & Company, of Thy le Château, in the beginning of 1884. About the end of 1883 two engineers of tracks and permanent way, Messrs. Brudder and Braet, were sent into Germany and England to inquire regarding results obtained in these countries with metallic supports. The reports of these engineers concluded with the rejection of all the systems used in Germany, such as those of the Haarman, Heindl and Elberfeld outline, which was adopted by the Berg & March Railway on account of the expense of maintenance and lack of stability, since all of their ties fairly dance up and down under the passage of the trains and were the occasion of great deformations of track. The whole track laid with Webb's metallic system, which was visited by these men at Crewe, in England, was found in a very good condition, and, according to the reports received on the spot from the officers of the heads of the Equipment Department of the London & Northwestern Railway, the expense of maintenance was not at all burdensome, and hardly exceeded that of laying fresh track in the ordinary way upon their standard chairs. In this system of track, which is distinguished by its heavy dimensions, the rails, which are double-headed, weigh about 30.3 lbs. per ft., and rest upon steel ties weighing 161 lbs. The first expense of laying has been found to be considerably above the most solid of the Belgian lines. No new trial of entirely metallic track has been made since the report of these men.



THE PAULET TIE.

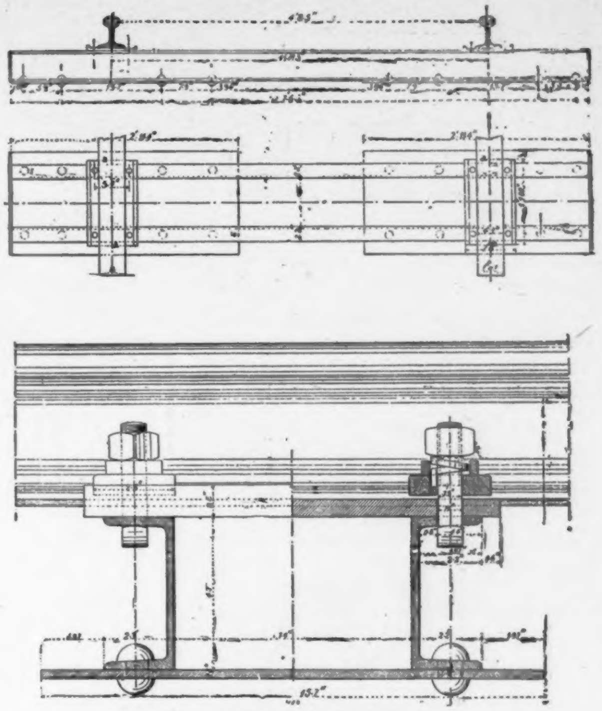
About the end of the year 1884 our international shops at Saraing, through the influence of its General Manager, M. Sadoin, pointed out to the Minister of Railways, Posts and Telegraphs the necessity of metallic supports on the Belgian railways, and proposed that he send a delegation of engineers into Germany, instructed to re examine the different systems of metallic supports which were used at that time on the other side of the Rhine. On receipt of this request the Belgian Government, which is always desirous of coming to the assistance of its national industries, appointed Messrs. Brudder and Tondelier, who were engineers of the Belgian State Railroads, to join a delegation sent by Cockerell, consisting of Baron Macar and Mr. Van Haesendenck. A remarkable report was drawn up by these engineers on their return from Germany, which, without being conclusive either for the adoption or rejection of any of the types examined, stated that, in the opinions of the German engineers, the best ties among those tested were those of the Elberfeld type, those of the Belgian State Railway, which were in the form of a hat, and those of Alsace and Lorraine, whose outline was that of a slightly modified Vautherin type. This report added that the Elberfeld tie beds itself well into the ballast, but does not offer sufficient resistance to the longitudinal sliding of the rail, and that its height is insufficient; that the hat-form tie of the Prussian State Railway is not easily tamped, and is not sufficiently strong at the bending joints; that the Alsace and Lorraine tie, with some of its dimensions slightly increased and strengthened, would be suitable for further testing.

In consequence of this report the management of the State Railways proposed to make a trial

1. Of the Alsace and Lorraine tie, improved as indicated above;

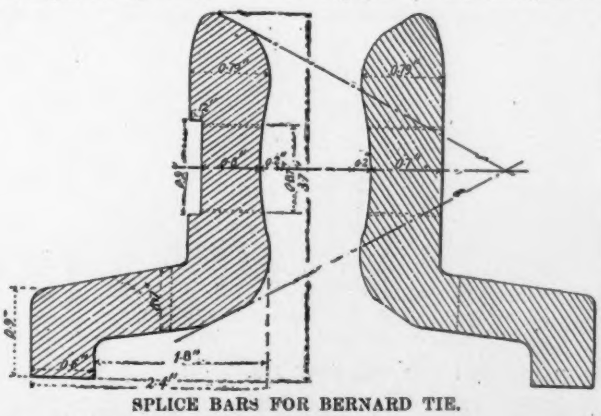
2. Of the Paulet tie (see engraving), which had been experimented with on branch lines, and which appeared at first sight to give good results. The State Railway of France had also just decided to make a trial on the Angeres line. At the same

time that the management made these propositions to the government the discussion of the railway budget was opened. Several members of the Chamber of Representatives, yielding to the desires expressed by the iron industries, urged very vigorously from the tribune that a new test upon a large scale should be made of metallic ties. The matter could not remain without some favorable consideration, and Mr. Vanden-



THE BERNARD TIE.

feereboom, Minister of Railways, took it upon himself to make a contract for the furnishing of 75,000 ties made up as follows: 25,000 metallic ties of Bernard type, designed by Mr. Bernard, who is Chief Engineer of the Northern Railway Company; 25,000 ties designed by Mr. Post, Chief Engineer of the Netherland State Railways; 25,000 ties designed by Mr. Braet, Engineer to the Minister of Belgian State Railways. These lots were ordered from the steel works of Couillet, of Angleur, of Seraing (Cockerill), who had given a bid of 149.5 francs, 119 francs and 119.5 francs per ton. The weight of these three types of metallic supports was taken by the management as equal respectively to 231.5 lbs., 165 lbs. and 165 lbs., which was considerably above that of the ties which had been previously tested. The adoption of this increase of



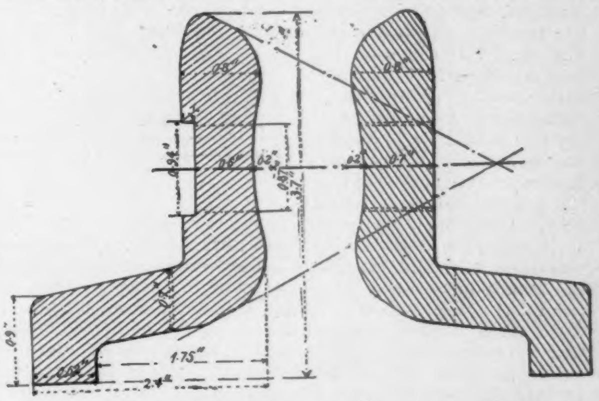
SPLICE BARS FOR BERNARD TIE.

weight was for the purpose of increasing the capacity for wear—that is to say, the durability of the supports, and in addition to stability the strengthening their resistance to bending strains; for it had been decided by the government that it would undertake a last experiment, in order to determine whether the replacing of wooden ties by those made of metal could give advantageous results.

It was furthermore decided that the trial in question should be made for the sake of a comparison of the three systems of entirely metallic track, by placing them under identically the same conditions of wear and with the same profile, alignement, and the amount of traffic which would pass over them. It may be added that in order to arrive at conclusive results they chose locations for placing the ties where the traffic was very rapid and heavy. Before passing on to the results which have thus far been obtained, it would not be devoid of interest, we think, if we gave a brief description of each of these ties—the Bernard, Post and the Braet.

Bernard Ties.—The Bernard ties tested on the lines of the Belgian State Railways were composed of two iron channel bars 7 ft. 6 6 in. long, attached at the bottom by two sheets 2 ft. 11 in. in length, riveted at their ends by eight rivets each. These sheets are bent up against the ends so as to close the trough of the tie, thus opposing a flat surface against the ballast in order to overcome all tendency toward lateral displacement. The rails were placed on the ties with the interposition of sole pieces or tie plates, which had an inclination of 1 in 20, and were provided on each side with an upward projecting clip. The rail was fastened to the tie by means of clips and bolts. In the arrangement adopted there were eight ties to each rail of 29 ft. 6.3 in. in length. The arrangement adopted by Mr. Bernard, in order to avoid the shearing off of the bolts, is as follows: The nut of the bolt is provided at its lower end with radial teeth, so that the annular nut-lock, which is in the form of a spiral and is placed between the nut and the clip, will hold better. Fig. 1 shows the general form of this spring. The lower end terminates by a vertical arm, which catches in a groove cut into the inside of the clip.

Post Ties.—The Post tie, which is in the form of an inverted trough, is the derivative of the Vautherin type, which was designed in France in 1863, at Fraisans, by Mr. Vautherin, at the Franche-Comte Works. It has a length of 8 ft. 2.4 in. and weighs 171 lbs. The incline of 1 in 20, which generally obtained in other systems of metallic ties, is easily realized, either by means of the Haarman arrangement, which consists of the interposition between the flange of the rail and the top of the tie of a sole tie-plate, or by means of the Hasch-Lichthammer device, which consists of obtaining this inclination at



SPLICE BARS FOR POST TIE.

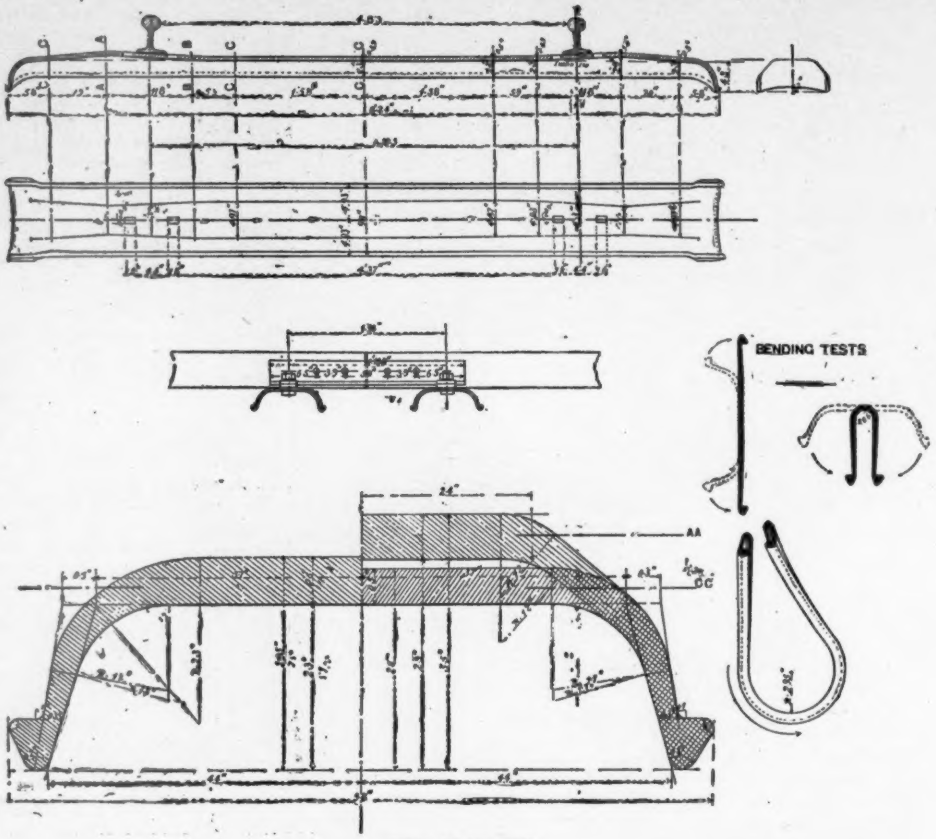
the point of the support of the rails by stamping the tie when it is hot and giving it a concave outline in its longitudinal direction; and this has been done by Mr. Post by another process, in a way that does not deform the tie and in no way injures its stability. He has given this deformation to the surface of the support of the rail by rolling the tie, either with triple rolls or with a reversible roll by means of a special arrangement of the last grooving of the finishing rolls, and by taking care to obtain an excess of thickness of the metal at that portion which has to bear the greatest amount of fatigue.

As for the method of attachments, it consists of clips and bolts, with an interposition between the bolt and the clip of a nut of the double grooved or elastic type, which is in the form of a spiral arrangement which opposes unscrewing. This washer has a winged plate raised against one of the faces of the nut which was lately employed by the Belgian State Railway on the Vautherin ties. The elevation of the outside rail on curves is obtained by means of clips of different thicknesses, which are used sometimes in one direction and sometimes in another. The longitudinal sliding of the rails is avoided, in the case of supported joints, where the distance from center to center of ties is 1 ft. 9.7 in., by the use of angle-bars with a vertical prolongation coming down so as to abut against the clips.

By closing the ends of the ties, by stamping down these ends under a press when hot, and by doing away with the horizontal rings and limiting the lower part of the support and their displacement by straight walls in the form of a knife which

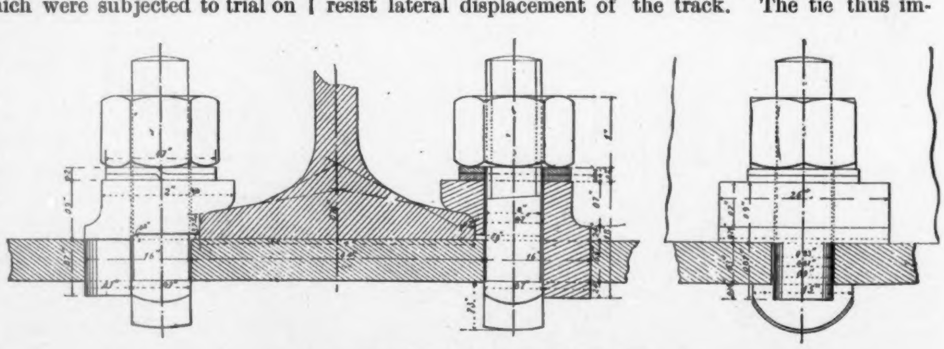
cuts into the soil, Mr. Post has succeeded in overcoming a tendency of the tie to empty itself of its ballast. The latter is now imprisoned as though it were in a hollow, cannot free itself from the compression to which it is subjected, and opposes a strong resistance to the lateral displacement, especially on curves, and the whipping due to the passage of trains is almost entirely avoided.

Braet Ties.—The Braet tie is nothing else than a modified form of the Post tie. The designer endeavored to approach in the transverse section of his support the circular form of equal resistance, and to give a greater rigidity to the track by retaining under the supports the greatest possible amount of ballast. The extreme outside edges of the tie are vertical, thus facilitating its penetration into the ballast, and they end, as in the Post tie, with strengthening pieces which protect the metal at this point against the blows of the tamping irons. The number of ties in laying the Braet track, as in the Post, was made 12 for each rail of 29 ft. 6.3 in. in length.



THE POST TIE.

Results Obtained up to the Present Time.—Instead of distributing the ties to be tested over lines of various degrees of importance, the management, as we have already said, have them in use on the main lines which are doing the heaviest business, and on those where the speed of the trains is the highest. The test was therefore conducted so that the results would permit of the formation of a conclusion, and the test would be in a certain way a final one, and especially favorable to the metallic ties if the results had been satisfactory. Unfortunately these results have, unquestionably, been unfavorable, and it might almost be said that they have been disastrous, not only from the standpoint of the preservation of the supports, but also from that of the ordinary expense of maintenance of the tracks. Yet it must be remembered that nothing was neglected in order that the systems of ties tested should be capable of sustaining successfully all strains to which they might be subjected. During the course of the last year there was a most careful inspection made of the ties which were subjected to trial on the principal lines of the Belgian roads. After five years of service it may be stated that from 40 to 50 per cent. of the Braet ties showed cracks at the point of fastening, and these cracks were frequently as long as 1.1 in. The Post ties showed results less favorable still, only 20 per cent. having been found in good condition. In order to avoid these cracks, which were often produced in the steel when the holes are made on a punching machine, the edges of the holes were reamed out to a depth of .078 in. On the line between Brussels and Antwerp 77 per cent. of the Braet ties which were examined were found to be cracked, and 18 per cent. of the Post ties were in the same condition. Sometimes these cracks had attained a length of 1.96, 2.36 and even 2.75 in.; 5,000 riveted ties of the Braet type were removed from the track after only a few months of service. From the standpoint of preservation of the ties, the result of this test has therefore been most disastrous, and it was still more so from the standpoint of expense of maintenance. Points of observation were established along the different lines of the system. They were composed of sections laid side by side, in the same portions of the line under the same conditions of fatigue, and metallic ties of the Post and Braet systems. The exact account of the time which was spent by the graders and trackmen in caring for both types of track was kept by the men in charge of these observations.


RAIL FASTENING FOR THE POST TIE.

The reports which were rendered on the line from Malines to Tirlemont gives as a result of the observation of this part of the track, which had the same length and was laid respectively with wooden ties, and the Post and Braet metallic ties, the hours devoted to each, as indicated above, was 356, 1,015 and 1,505 respectively, showing that the average of the work on the metallic ties was more than three times the amount of that required by the wooden. Such difference as this demands some kind of explanation. One of the first causes of this elevation of the cost of maintenance of metallic ties is that the metallic tie is hollow, and that the ends are closed in order to resist lateral displacement of the track. The tie thus imprisons in the hollow space beneath it a quantity of ballast, which soon becomes hard and compact. Then if the track requires redressing horizontally, it is necessary, first of all, to accomplish it by demolishing this mass of ballast. That is one of the difficulties which does not exist on a track laid on wooden ties, where it is merely necessary to remove the ballast which is banked up against one of the ends of the ties. The form of the tie renders it equally difficult to tamp the track properly. Finally, the last cause of this excessive expense of maintenance is not the least, and that is it causes a rapid deterioration of the ballast under its whole length.

Mr. Flamache, who is Chief Engineer of the Belgian State Railways and Professor of the Course of Railway Exploitations at the University of Gand, presented a paper at the International Congress of Railways at St. Petersburg, giving the result of his researches on the deflection of the rail on the passage of trains.* The rail begins by rising above its normal place just ahead of the first wheel of the engine, it then lowers at the passage of each wheel, to rise again immediately between that and the passage of the next wheel, but in a proportion variable with the speed of the train and without exceeding at this time the normal plane of the track.

In the successive upward and downward movement the tie is constantly grinding the ballast, and the gravel which is in immediate contact with the hard metal is worn, broken and reduced to an impalpable powder. The hardest ballast is, therefore, at the end of a short time mixed with a certain quantity of fine powder. Then the rain comes, which percolates down through the ballast and the powder and reduces the latter to a mud. The upward and downward movement of the tie, which is hollow on the under side, therefore produces a partial vacuum, a suction and pumping action which draws the water down into the ballast beneath the tie and into the dust and mud which is mingled with it. At the end of a comparatively short time, then, the tie is buried in a mud ballast, which renders the track unstable, and which as soon as it dries forms a compact mass beneath the tie, which renders the work of track dressing so difficult. The only remedy for this state of affairs consists in either sifting the ballast through a screen, which is a very expensive operation, or of renewing it entirely.

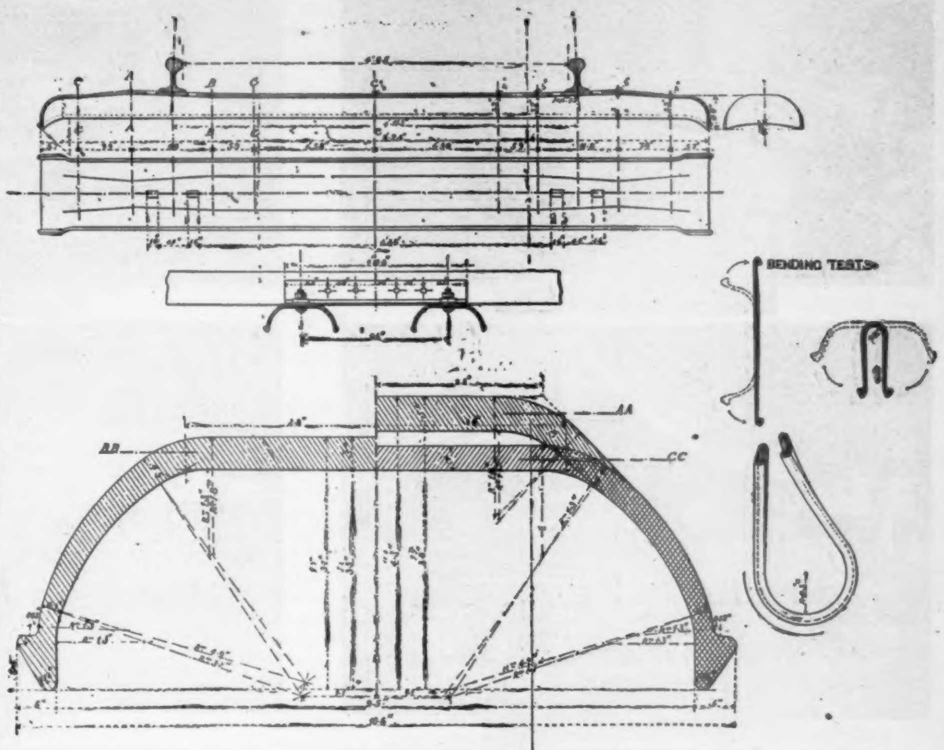
There is another point in the remarks which were made by Mr. Flamache which is of great importance. The diagram obtained directly by the registration of the movement and rail at the passage of trains shows that for low speeds and even average speeds the relative upward movement of the track after the passage of each axle remains practically very slight. It is only after a speed of 43.5 miles per hour is exceeded that these movements are suddenly exaggerated and their amplitude increased more rapidly than the speed itself. Finally, we think, with a great number of other engineers of permanent way, that metallic ties are hardly in a position yet to give good results on tracks where trains run at a speed greater than 43.5 per hour, at which speed the abnormal movements of the rails increase very rapidly, but we think that on some portions of the line which are run at lower speeds, these ties would give satisfactory results on condition that a proper ballast of good quality was used, but that they are less advantageous, economically speaking, than wooden ties, which give the only practicable elastic track thus far attainable.

THE CHINESE IMPERIAL RAILWAY.

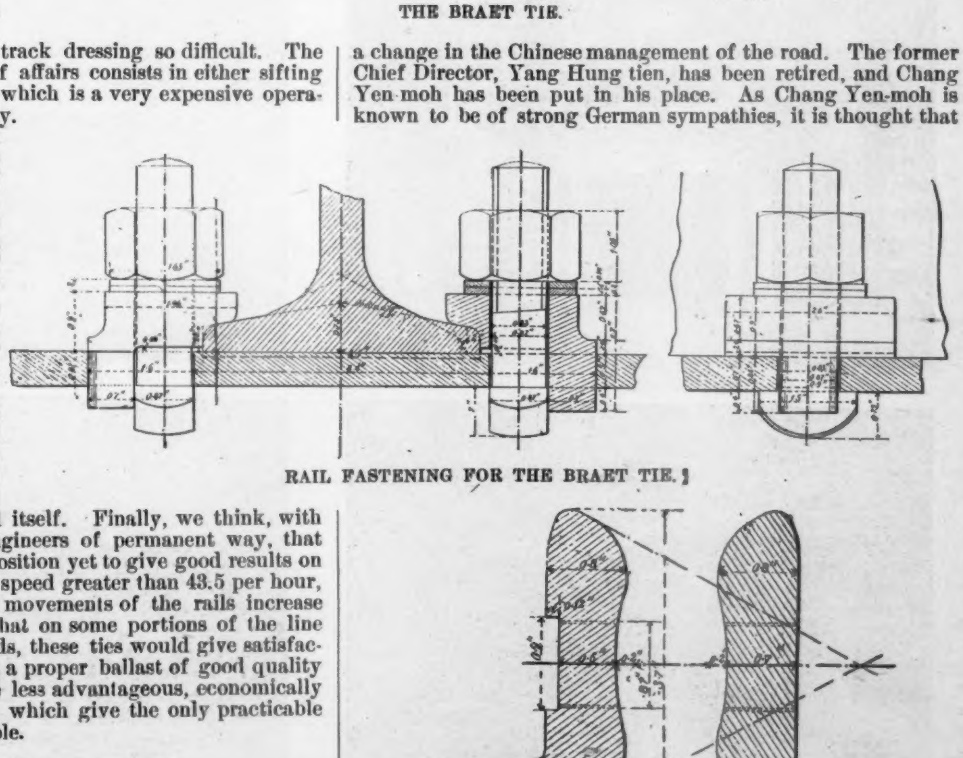
From a correspondent in China we learn that Mr. W. N. Pettrick has resigned his position as Assistant Managing Director of this company, and with his departure all prospect of applying American railroad methods in China is over.

Mr. Pettrick attempted to introduce the Westinghouse air brake, but the English engineers did not look with favor upon the innovation; and now, although two locomotives are fitted with the brake, no use is being made of it.

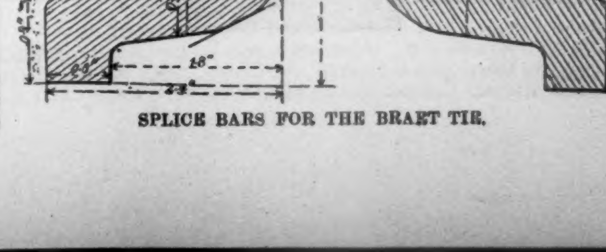
Immediately following Mr. Pettrick's resignation there was a change in the Chinese management of the road. The former Chief Director, Yang Hung tien, has been retired, and Chang Yen-moh has been put in his place. As Chang Yen-moh is known to be of strong German sympathies, it is thought that



THE BRAET TIE.



RAIL FASTENING FOR THE BRAET TIE.



SPLICE BARS FOR THE BRAET TIE.

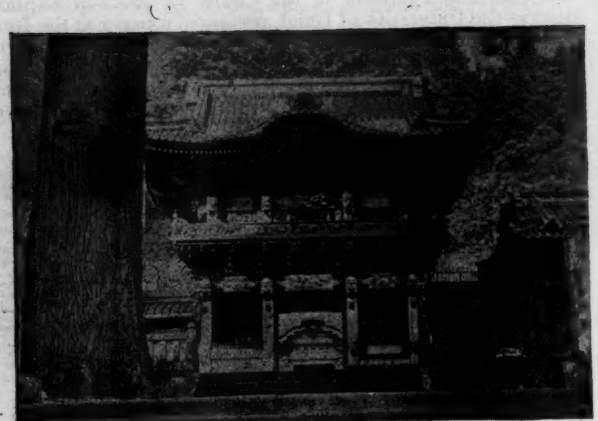
* See American Engineer, August, 1893.

1. MIHASHI, (SACRED BRIDGE)

2. TAKARAGURAS, (GO-DOWNS)

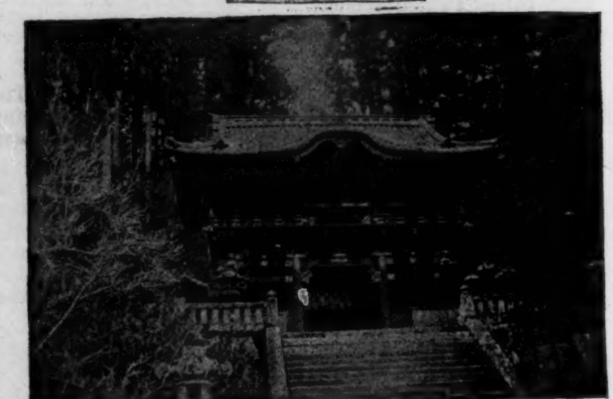
3. WATER CISTERN

4. LANTERN, (COREAN)



5. YOMEIMON, (GATE)

6. KARAMON, (GATE)



7. NITENMON, (GATE)

8. YASHAMON, (GATE)

NIKKO TEMPLES.

the German influence will now be the dominant foreign influence in railroad affairs. As yet nothing definite has transpired in that way.

The work on the Lan River bridge continues under C. W. Kinder, Engineer-in-Chief, and the railroad is being extended toward the north. It will reach Shan-hai-kwan, the military town at the eastern terminus of the Great Wall, this year.

It is now decided to run a branch line from Port Arthur, at the entrance to the Pe-chi-li Gulf, to New-chuang (?), so connecting Port Arthur with the military road from Tientsin to Kirin. Tenders for 4,000 tons of rails to be landed at Port Arthur not later than September 30 have been invited.

New iron works to be located at Tangshan, under German auspices, are projected, but their plans have not been definitely settled yet.

NIKKO TEMPLES.

The range of mountains known as Nikkozan is situated on the northwestern boundary of the province of Shimotsuke, in the southeastern part of the island of Nippon.

The highest point of the mountains lies in 140° 10′ north longitude. Its highest peak, Nantaizan, is 4,680 ft. above the sea, and 820 ft. above the lake of Chiuzenji (estimated to be about 3,850 ft.), lying at its northern base.

The name Nikko is well known to all Japanese and foreigners who have visited the most remarkable places in Japan, for its beautiful natural scenery and splendid temples, buildings, etc. The original name was Futa-ara-yama (the two storm mountains) on account of periodical hurricanes in spring and autumn, which issued from a great cavern in the mountain on the northeast of Chiuzenji Lake, and this name, being translated into Chinese, became Nikkorzan. In the year 820, the priest Kukai (or Kobo Daishi) visited the mountain, made a road to the neighborhood of the cavern, and changed the name Futa-ara-yama to Nikkozan (or the "mountain of sun's brightness"), from which time the storms ceased to devastate the country. Up to the end of the seventeenth century a family of Shinto priests named Ono used to pay two visits every year to the cavern to perform certain exorcisms, the secret of which had been imparted to their ancestor by Kukai, and the effect was to keep the great storms quiet; it does not appear, however, that the discontinuance of this practice has had any evil results.

The sanctity of Nikkorzan dates from the year A.D. 767, when the Buddhist saint, Shodo Shonin, first visited it. Later on, in the beginning of the ninth century, Kobo Daishi, and in the middle of that century the priest Jikaku Daishi, added its sacred places.

In the year 1616, when the priest Ten Kai, afterward canonized as Jigen Daishi, was abbot, the second Shogun Hidetada, acting on the dying injunctions of his father, sent Honda Kadzusa no-suke and Todo Idzumi-no-kami to Nikko to find a resting-place for the body of Iyeyasu. They selected a site for the shrine on the southern slope of a hill called Hotoke Iwa, behind the temple where the Gongen of Nikko had been enshrined from ancient times, and returned to Yedo (Tokyo) on the 21st of the ninth month of the Japanese calendar with a plan of the spot for the information of His Highness.

Kadzusa-no-suke was appointed chief superintendent of the works, and the buildings were commenced on the 17th of the eleventh month of the same year. In the third month of 1617 the shrine and some of the surrounding edifices were completed. On the 15th of the same month the corpse was removed from Ku-no-zan, in Suruga, where it had been temporarily interred, and the funeral procession started for Nikko, where it arrived at two o'clock in the afternoon of the fourth day of the fourth month. On the eighth day the coffin was deposited in the tomb.

On the 11th Shogun Hidetada paid a visit to the shrine, and three days later the title of Sho-ichi-i Daigongen (first rank) was conferred on the deified hero by a decree of the Mikado (Emperor of Japan), which was read by his envoy, Ano Saishio, a Kuge (emperor's subject).

On the 17th the Gohei (shreds of paper attached to a long wand finely decorated) was presented at the chapel by the Imperial Envoy, and on the following day offerings were made at the shrine by the local Buddha Yakushi.

During the 20th, 21st and 23d days of the same month the Hokke Sacred Classic was read 10,000 times by priests assembled for that purpose. Many Kuge and a priest belonging to the Imperial family took part in the proceedings.

In the year 1644 the Abbot Tenkai (a wise man who has been respected by first Shogun Iyeyasu and his successors) died and was succeeded by the Monzeki, of Bishamondo, a son of the Sadaijin Kwa-zan-In-Sadahiro, who resigned his office 10 years later and returned to Kyoto.

The second Monzeki was the Priest-Prince Morizumi, the fifth son of the Emperor Go-Midzu-no-o. From his time down to the revolution in 1868 the chief priest of Nikko and Toyeizan (Uyeno) had always been a prince of the Imperial blood. He usually resided in Yedo (Tokyo), and visited Nikko three times a year—namely, at the new year, in fourth and ninth months.

The title of Dai Gongen was changed to that of Miya or Goo in the year 1645 by decree of the Emperor, conveyed by his envoy, the Dai-na-gon Kikutei Tsune Saye. There are only 21 shrines in Japan known as Goo, the highest title which can be given to them. Miya or Goo means palace, and Tosho means the light of east, in allusion to the seat of Iyeyasu's glory having been in the eastern part of Japan, and to the benefits he conferred upon this country by putting an end to the civil war which had distracted it for so many generations.

Iyemitsu, the third Shogun of Tokugawa, who consolidated the power established by his grandfather, died on the 20th of the fourth month of 1651, and was buried within the grounds of the shrine of Nikko on the sixth day of the fifth month of the same year. The posthumous title Taiyu In Den was conferred upon him by the Emperor.

1. Mihashi (Sacred Bridge).

On issuing from the gate at the top of the street called Hatsuishi, and proceeding a few steps, one of the first objects which strikes the visitor is a crimson bridge spanning the rushing stream of Daiza-gaiva, about 30 yds. wide between the stone walls which confine its course at this point. It is supported by stone piers of great solidity, fixed into the rocks between which the stream flows, and though not claiming any particular architectural merit, is interesting from the fact that it was formerly closed to all passengers except the Shoguns and pilgrims twice a year. It is called Mihashi, or the sacred bridge. The legend says that when the holy Shodo Shonin first visited Nikko and arrived at this spot, he found the rocks so steep and the flood which rushed between them so full of whirlpools, that it seemed impossible to pass over. Appalled at the sight he fell on his knees and called fervently upon the gods and upon Buddha for aid, when, in answer to his prayer, there appeared on the opposite bank the indistinct figure of the god Shusha Daio holding two green and red snakes, which he cast over the abyss. In an instant a long bridge was seen to span over the stream like a rainbow floating among the hills. So great was the astonishment of the saint, that he doubted the reality of the miracle, but became fully convinced of the practical intervention of the god when the bridge in another moment became covered with long grass. Feeling quite satisfied about the safety of the structure, he crossed it with his disciples, and on turning round to look at it again saw, to his wonder, that the god and the snakes had completely disappeared.

The present bridge, which is 84 ft. long and 18 ft. wide, was built in 1636, and has not required any repairs of importance since that time. At each end there are gates, which are constantly closed.

The shrine of the god Shusha Daio stands on the side of the road opposite to the northern end. Forty yds. or so lower down the stream is the temporary bridge, successor to that which was constructed while the sacred bridge was in course of construction.

2. Takaragura (Go-Downs).

Enclosed by a wooden wall painted bright red there are, firstly, three buildings which are so beautiful that it seems a profanation to call them go-downs, but they are nothing more in reality. One is said to contain the utensils used at the ceremonies performed in honor of Iyeyasu's memory; the second contains pictures and Buddhist scriptures; and in the third are deposited furniture and other articles used by the hero during his lifetime.

The buildings are arranged in a zigzag form, the third being remarkable for two extraordinarily painted carvings of elephants on the side toward the gate. They are ascribed to Hidari Jingoro, a left-handed sculptor, who was very celebrated for fine arts of sculptures. It will be noticed that the joints of the hind legs are represented as bent in a weary way.

3. Water Cistern.

An interesting object is the water cistern made of a solid piece of granite and protected by a roof supported upon 12 square pillars of the same stone. It is so carefully adjusted that the water, conducted through a long series of pipes from the cascade called Somen-ga-taki behind the hill, bubbles up

and pours over each edge in exactly equal volumes, so that it seems to be a solid block of water rather than a piece of stone. The honor is due to Nabeshima Shina-no-no-Kami (Prince of Hizen), who presented it in 1618.

4. LANTERN (COREAN).

This is also a fine solid piece of workmanship, but its style and construction indicate that the credit of its manufacture is not due to artisans of Corea. We should be inclined to say that all three of these gifts came from Europe through Dutch hands, and the form of some bracket candlesticks, which are attached to the interior wall of the court and left of the steps, suggests that the whole set may have been the spoil of some Roman Catholic church in the Netherlands. No Corean or Liukuin ever made a candlestick with a hollow socket for the candle.

Nothing else remains to be observed in this court except two iron standard lanterns on the right of the steps, presented by Date Masamune, Prince of Sendai, a prominent adherent of Iyeyasu, and the same number on the left, given by the Prince of Satsuma. The whole number of such lanterns contributed by various Daimios amount to 118.

5. YOMEIMON (GATE).

This gate stands on the platform, after ascending a flight of steps, and is a marvel of workmanship. Photo 5 shows the front view and 6 the back view of the gate. Wooden columns of Keyaki timber are painted white as well as the interior of the side inches, which are lined with arabesques of graceful design founded upon the "botan" (mountain flowers).

The capitals of the columns are formed by the heads of fabulous animals called Kirin. Above the architraves the railing protects a balcony which runs all round the structure, supported by dragons' heads, with two white dragons fighting in the central space. Underneath are a row of groups of holy children playing, and other subjects, nine on each side. Below, again, is a curious network of beams and seven groups of Chinese sages. The roof is supported by gilt dragons' heads with gaping crimson throats, and from the top a gilt demon looks down upon the spectator. On the right and left extend a long piazza, the white walls of which are adorned with magnificent carvings of trees, birds, and flowers colored after nature. There are 15 compartments on the right and six on the left.

6. KARAMON (GATE).

This is composed of Chinese woods inlaid with great skill and care. The chapel is not open to the Japanese public, who are not admitted further than the bottom of the front steps, surmounted by the usual mirror. Foreigners and some classes of natives are not permitted access to it.

The front hall is a large matted room, 42 ft. long by 27 ft. from back to front, with two antechambers, one on each side. That on the right was intended for the use of the Shogun, and contains, besides pictures of Kirinona, gold ground, four carved oaken panels 8 ft. high by 6 ft. wide. The subjects are the phœnix variously treated, and appear at first to be in low relief, but on closer examination it will be discovered that the figures are formed of various woods glued to the surface of the panel, a suspicion of which fact is also naturally excited by a quantity of false headed nails, which do not add to the beauty of the work. The same number of panels, the subject of which are eagles, very spiritedly executed, exist in the opposite antechamber, called the waiting-room of His Highness, the abbot.

The golden Gohei, in the center of the front chapel, is the only ornament left, the Buddhist furniture of bells, gongs, books of prayers, etc., having been removed. Two wide steps at the back lead down into that part of the chapel called the stone chamber, from the circumstance that it is paved with that material. The ceiling is divided into square panels, painted with golden dragons on a dark blue ground. Beyond are some gilded doors leading into the Honden (principal chapel), containing four apartments, to which access is not obtainable. In the first stood formerly the Gohei, in the last probably the Ihai (a tablet inscribed with the name of Toshogu).

7. NITENMON (GATE).

The niches on the outside contain a green wooden statue on the right and a red one on the left. One of the niches on the inside is occupied by the God of Wind, painted green, who carries on his back a long sack tied at each end, with the ends brought on his shoulders. He has only two toes on each foot and a thumb and three fingers on each hand. His companion, the God of Thunder, is painted red, and holds a thunderbolt in his right hand. He has the same number of toes as the God of Wind, and one finger less on each hand. The name Nitenmon means gate of the two heavenly gods of wind and thunder.

8. YASHAMON (GATE).

This gate stands three more flights of steps distant from the above gate, the niches of which contain four Yasha, Buddhist gods, who protect the four quarters of the compass.

THE FASTENINGS OF RAILS TO WOODEN TIES.

BY JULES MICHEL.

FOR some time engineers have been turning their attention toward the substitution of wood screw fastenings for spikes or pins, which are driven into place by blows of a hammer, in fastening rails to wooden cross ties. This question, which is of more importance for rails which rest directly upon their flanges than for double-headed rails which are carried by chairs, was discussed at the International Congress of Railways at Paris, and afterward at the Congress of St. Petersburg. It has given rise to very different opinions, doubtless because those most interested do not agree upon the type of fastening which they would use. The result is that while wood screws are very severely criticised in some countries, they have given the best of satisfaction elsewhere.

In order to bring the question to a definite focus, I would like to recapitulate some experiments which have been made during the past twenty years upon a large scale by the Paris & Lyons system of railways to illustrate the type which has been evolved as the result of these experiments and to indicate the modifications of which it would appear susceptible.

Since 1863 the Paris, Lyons & Mediterranean Railway have used an iron screw for fastening their rails; this screw was cut cold, and the threaded portion had a length of 4.9 in. Fig. 1.—The diameter of the head was .8 in., while the body of the screw was only .55 in., leaving a projection on each side of .12 in. for the thread, the pitch of which was .3 in.; the base of the triangle forming the thread was .16 in., and was divided into two unequal parts of .06 in. and .10 in. by the perpendicular let fall from the apex. This fastening seems to have been very carefully designed, especially when compared with the lag screws or screw spikes used for some years previously in Germany.

Fig. 2 shows the fastening used on the railways of the Grand Duchy of Baden previous to 1860; they started it by striking with a hammer just as they did also the spike shown in fig. 3. The hole was not bored in advance; and it will readily be understood that under these conditions the fastening would destroy the fibers of the wood and would give poor results as a method of fastening the rails to the tie.

The fastening of the Paris, Lyons & Mediterranean Company was started in a hole .63 in. in diameter, which was bored with a bit into hard wood, either oak or beech. It had the inconvenience of taking some time to fasten, and the wood which lay in contact with the body of the screw between the thread was only .14 in., and this was found to be insufficient. Its use, therefore, was limited to changes which were made in the track, and efforts were made to improve the spike, to which, after a number of tests, the form of the octagonal prism shown in fig. 4 was given.

This spike gave very good results; and recently some foreign engineers, who have adopted it on account of its superiority over other types of spikes, have told me that the results were perfectly satisfactory to them, and they could see no need of replacing it with a screw spike.

It has a length of 5.9 in, including the head; the prismatic body is made with a vertical distance of .75 in. between faces and .8 in. across the angles. It is fastened by blows of a hammer into a hole previously bored with a bit having a diameter of .63 in. It shows considerable resistance on entering, and compresses the fibers of the wood. In the July issue (1884) of the *Revue Generale des Chemins de Fer* I gave the resistance which it offered to pulling in different kinds of wood—that is to say, it shows from 3,970 lbs. to 5,750 lbs. in hard wood. The spike weighs .77 lb., and costs on an average about two cents apiece.

But with the development of the track and the increase of speeds, the resistance which this spike offered to pulling seemed insufficient, and engineers have turned their attention toward the substitution of screw spikes.

Since 1863 the Northern and Eastern Railway companies,

whose types of spikes are shown in figs. 5 and 6, have found them to be very defective, and have had recourse to the screw spikes shown in fig. 7 for use with wooden ties on their main line. These screws have about the same dimensions as those of the Paris, Lyons & Mediterranean Company, shown in fig. 1, which bears a close resemblance to that shown for the Eastern Company.

In 1875, in consequence of the experiments which were given in detail in the July number of the *Revue Generale des Chemins de Fer* for 1884, the screw spike was adopted by the Lyons Company to the exclusion of the ordinary spike, and it was given the form shown in fig. 8, which bears a strong resemblance to the type of the Northern Railway Company, but which was considerably improved by increasing the pitch of the thread. The prism of wood included between the two threads which must resist the pulling had a height of about .39 in. instead of .27 in.* Its resistance was therefore theoretically about double, and the fibers of wood were better arranged during the operation of putting it in position.

At the same time the question of the use of the screw spike was discussed at the union of German railways, and afterward at the eighth reunion of the Verein in Stuttgart in 1878. The committee concluded by recommending the use of screw spikes instead of ordinary spikes for fastening rails to the ties.

The screw spikes adopted by the Paris, Lyons & Mediterranean Company was first manufactured of iron and the thread cut cold. About 1878 they tried to manufacture the threads by hammering hot in suitable dies. This hammering produced a useful shaping of the material, but it required great skill on the part of the workmen, and very frequently the threading was defective. Nevertheless, it was used, together with the cold threading, to facilitate the production in the large quantities necessary for the consumption of the old and new lines, the latter of which showed a development of about 124.27 miles per year.

But the shaping of the metal to obtain the hexagonal head adopted in imitation of the Northern Railway Company's type was a somewhat delicate operation. It required so much heating that the iron was frequently burned and the head of the screw was sometimes torn off. The wrench which was used for driving and withdrawing the spike was of such unwieldy dimensions that breakages and twistings were caused by the strains to which the spikes were submitted, or the thread began to cut into the body of the screw, so that the resistance of the metal was insufficient to carry the strains.

As soon as the conclusion was reached that it was necessary to increase the solidity of the track attachments the dimensions of the body of the screw were increased, just as the Northern and Eastern Railway companies, who had found the same disadvantage, and had adopted an iron screw spike .9 in in diameter with a diameter at the base of the thread of .67 in. instead of .55 in., which they had previously used, had been obliged to do. This is the dimension which is still used by these companies. Figs. 9 and 10 show the last type of screw spike adopted by the Northern and Eastern Railway companies, and fig. 11 is the type used by the Belgian State Railways for the Goliath type of the Vignole rail.

But as the change in the diameter of the attachments on the tracks of the Paris, Lyons & Mediterranean Company, where they use chairs having holes .8 in. in diameter, could not be made without redrilling all these holes, they decided, after a certain number of tests, to have recourse to steel in order to secure greater resistance against rupture ; at the same time they adopted the spherical form for the head like the Eastern Railway Company, fig. 7. This was done in 1881, and since that time the use of steel has been adopted in the regular manufacture of the heads of the screw spikes, and furthermore threading them cold by rolling by means of a three-roller machine.

These machines were not successful with iron because they caused cold shuts, but have given excellent results with steel. A single machine can turn out about three thousand screw spikes per day without overworking the attendant who controls it, and without the rapidity of the operation injuring in any way the regularity of the output.

Finally, in 1889 new experiments were undertaken to determine whether it would not be possible to increase the pitch of the thread for the sake of rendering the placing of the spikes more rapid without injuring their pulling resistance.

In consequence of these tests, which are given in *résumé* in the accompanying table, the scr. w spike (fig. 13) was adopted. It consists of nine spirals with a pitch of .5 in. The base of the thread is .12 in. ; the outline of the thread is a triangle intermediate between a rectangular and an isosceles triangle. The head is like a flattened cap surmounted like a square prism for the wrench which is used in driving it. It is manufactured hc̃ by rolling from mild steel, the tensile strength of which ranges from 101.4 lbs. to 110.2 lbs., and an elongation of 25 to 28 per cent. The weight is .09 lbs., and it cost about three cents. It, therefore, costs one cent more than the old iron spike, but the pulling resistance is tripled, and there is no more trouble with the rails tearing the fastenings from the ties, as formerly occurred after a few months of service. This loosening of the fastenings caused a very injurious wearing of the flange on the chair or the tie, and permitted the sand of the ballast to get beneath the flange of the rail so that the wear was more or less rapid according to the intensity of the traffic.

The conclusion is, then, that the use of a screw spike of some carefully designed shape assures the stability of track and increases the life of the rails, chairs and ties.

It may be furthermore added that it never enters the mind of the track layers who have a cross-handled wrench to use a hammer to drive these screw spikes with threads either projecting or slightly inclined.

The hole into which they are driven should be from .55 in. to .59 in. in diameter, according to the diameter of the body of the spike and the nature of the wood of the tie, whether it be pine, oak or beech. The wood is compressed by the entrance of the threads, which force their way in, and the friction of the body upon the fibers of the wood compresses it still more, thus adding to the resistance of the threads which oppose any loosening of the spike. After they have been laid for a few weeks they are usually screwed up afresh, not because the spike is loosened in any way, but because the surface in contact—rails, chairs and ties—have, so to speak, effected their seating, and are exactly adjusted to each other by the pressure to which they have been subjected by the passage of the trains. From this time on the fastening is complete. The following table gives a *résumé* of the tests made in different ways by the permanent way department of the Paris, Lyons & Mediterranean Company :

STRAINS REQUIRED TO PULL SCREW SPIKES OF .8 IN. AND .9 IN. DIAMETER WITH A PITCH OF THREAD OF .4 IN. AND .6 IN. DRIVEN 4 IN. INTO VARIOUS KINDS OF WOOD OF DIFFERENT AGES.

NEW WOOD JUST PUT IN TRACK.

Date of Test.	Diameter of Spike.	Pitch of Thread.	Northern Pine.	Landes Fir.	Beech.	Oak.	Diameter of Hole in Wood.	Observations.
	In.	In.	Lbs.		Lbs.	Lbs.	In.	
1875....	.8	.4	5,700	....	9,500	9,000	.6	
1881....	.8	.4	..	....	10,000	10,600	.6	10 tests.
1889....	.8	.4	...	....	... ..	11,600	.55	Spikes rolled, 24 tests.
1889....	.8	.5	.....	....	.. ...	12,800	.55	20 tests.
1889....	.8	.6	.....	....	......	11,500	.55	10 tests.
1891....	.8	.5	7,600	11.4	......	.. ..	.55	
1889....	.9	.5	....	...	13	12,300	.67	4 tests.
WOOD THAT HAS BEEN IN TRACK FOR NINE YEARS.								
1889....	.8	.4	....	...	......	10,000	.55	10 tests.
1889....	.8	.5	....	....	.....	11,600	.55	

The conclusion reached from the tests of 1875 and 1881 is that the average resistance to pulling is the same in beech and in ordinary oak or about 9,900 lbs.

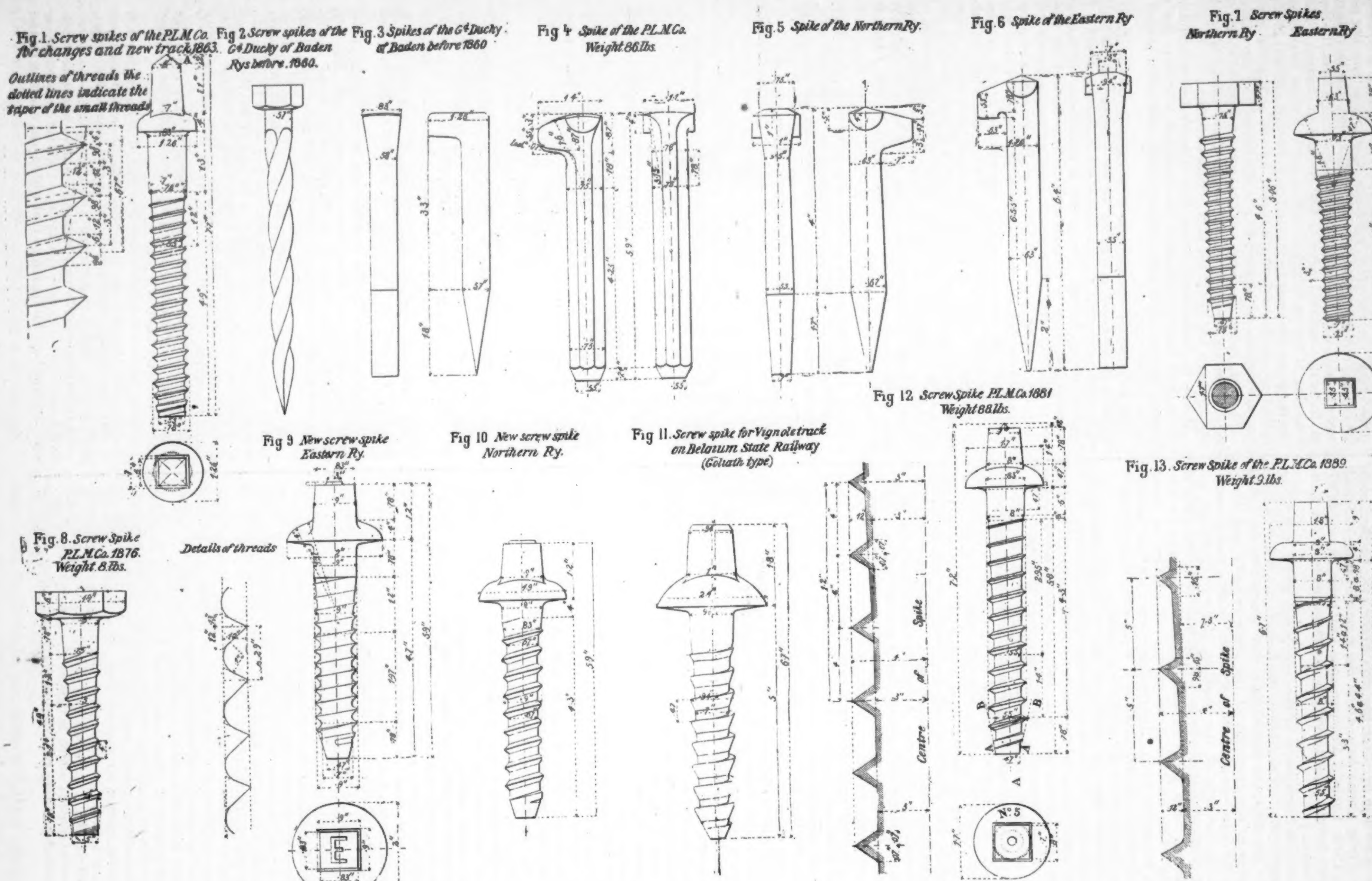
The improvement in the manufacture by rolling the screw spikes hot out of steel which was developed in 1889, added to the reduction in the diameter of the hole in the wood, has increased this resistance about 15 per cent. and raised it to 11,500 lbs.

The modification of the pitch which was raised from .4 in. to .5 in. has also increased this resistance by about 10 per cent., or raising it to 12,800 lbs. in fresh wood and 11,500 lbs. instead of 10,430 lbs. in wood that has been 9 years in service. This gives an average of 10,965 lbs. in ties as they are ordinarily found in service.

The increase of the pitch to .6 in. seemed to have the effect of lowering the resistance, which was only 12,300 lbs. against 12,800 lbs. with the pitch at .5 in.

Finally, the screw spike with a diameter of .9 in. and a pitch of .4 in. with the base of the thread only .12 in. did not seem to give any better results than the .8-in. screw spike with a pitch of .5 in. either in Northern pine or in oak.

An attempt was then made to give the thread a section which would be either an isosceles triangle, a right-angle triangle, or some intermediate form such as that which was adopted on the



TYPES OF FASTENINGS FOR RAILS AND WOODEN TIES.

Paris, Lyons & Mediterranean road in 1863 (fig. 1). Tests which were made in 1889 have given the following results as the strain which is required to pull different kinds of screw spikes .2 in., either in new oak or in ties which had been nine years in service.

Dimension of Spike.	Isosceles Triangle.	Rectangular Thread.	Observations.
Screw spike of	*.8 in. diameter.*		New tie.
Pitch of .4 in	11,680 lbs.	12,039 lbs.	Average of 4 tests.
Pitch of .6 in.	12,460.5 lbs.	12,513 lbs.	Average of 4 tests.
Pitch of .5 in.	13,000 lbs.	13,560.75 lbs.	Average of 4 tests.
Screw spike of	*.9 in. diameter.*		New tie.
Pitch of .5 in.	13,424 lbs.	13,424 lbs.	
Screw spike of	*.8 in. diameter.*		Tie having 9 years' service.
Pitch of .4 in.	10,253 lbs.	9,922 lbs.	
Pitch of .5 in.	10,238 lbs.	11,576.25 lbs.	
Screw spike of	*.9 in. diameter.*		Tie having 9 years' service.
Pitch of .5 in.	11,250 lbs.	11,020 lbs.	

These tests do not actually seem to give any preference to the rectangular form of thread over that of the isosceles triangle; hence the Lyons Company has kept the form which it has used for a long time, there being no reason for changing.

We can conclude from the tests given in the first table of this article what may be the capacity to resist pulling for oak which has been compressed by the introduction of threads of the spike .8 in. in diameter into its fibers. The resistance to pulling, according to the experiments of 1889, is 12,800 lbs. This is obtained by the pressure of nine coils of .12 projection and 11 × .7 in. as the average diameter, forming a total surface of 9 × .25 sq. in. = 2.25 sq. in., can by the friction of the body of the screw of .55 in. on a height equal to two-thirds of the body to which the spike has been driven, since the thread occupies .2 in. out of a height of the pitch, .5 in. Now, a direct test for a smooth stem .55 in. in height gives a resistance to pulling of 3,307 lbs. It may then be admitted that the body of the screw itself would produce a resistance of 2,205 lbs., thus leaving 10,639 lbs. for the pressure on a surface of 2.21 sq. in., which supposes a resistance of 4,459 lbs. in new wood.

For ties which have been nine years in service, the resistance would be only 9,371 lbs., or 4,200 lbs. per sq. in.

According to the tests published in 1884, the resistance of new oak to compression is 529.2 lbs.; the fibers of the wood bend back by the operation of the screwing of the spike would increase its resistance 40 per cent.

The steel of which these spikes are manufactured has a resistance to rupture of from 64,000 lbs. to 71,000 lbs. per sq. in. or 10 × ½ the resistance of the wood of the ties which have been several years in service on the tracks, to compression. It is not out of place to ask whether a better model of spike would not cause the two materials in contact—that is the steel and the wood—to work together up to the limit of resistance of which they are capable.

The Paris, Lyons & Mediterranean spike does not fulfill this definition, for the metallic center resists a strain of 15,435 to 17,640 lbs., giving an average of 16,537 lbs. before breaking, while the wood yields under a strain of 12,844 lbs. in wood nine years old, and 11,576 lbs. in old wood, giving an average of 12,120 lbs.

The surface of the threads would then be increased to the detriment of the body of the spike at least by increasing their number and lengthening the part covered by the thread. Supposing then that the diameter of .8 in. for the outside is retained, it would be necessary to give the body a diameter of .5 in. or a surface of .2 sq. in. instead of 2.4 sq. in., which the body of .55 in. gives. The resistance to rupture would then be only 12,780 lbs. for a steel spike. If the body had a diameter of .5 in., the threads would form a projection of .14 in. on each side. In a direction on a plane at right angles to the axis of the spike, each turn of the spiral would have a surface of 2¼ sq. in. If there are nine complete turns, the total surface of the thread brought to bear against the wood will be 2.56 sq. in. instead of 2.23 sq. in. as in the spike actually used, or an increase of .33 sq. in.

The resistance to pulling will then increase by .33 sq. in. × 740 lbs. or 259 lbs.—that is to say, instead of 12,120 lbs. we would have a resistance of 13,818 lbs., which is almost exactly equivalent to the tensile strength of the body of the spike. If instead of hard-wood ties, like oak or beech, soft-wood ties should be used, such as Northern pine, it would be necessary to increase still further the projection of the thread at the expense of the diameter of the body by basing it on the coefficient of resistance to compression of the soft woods.

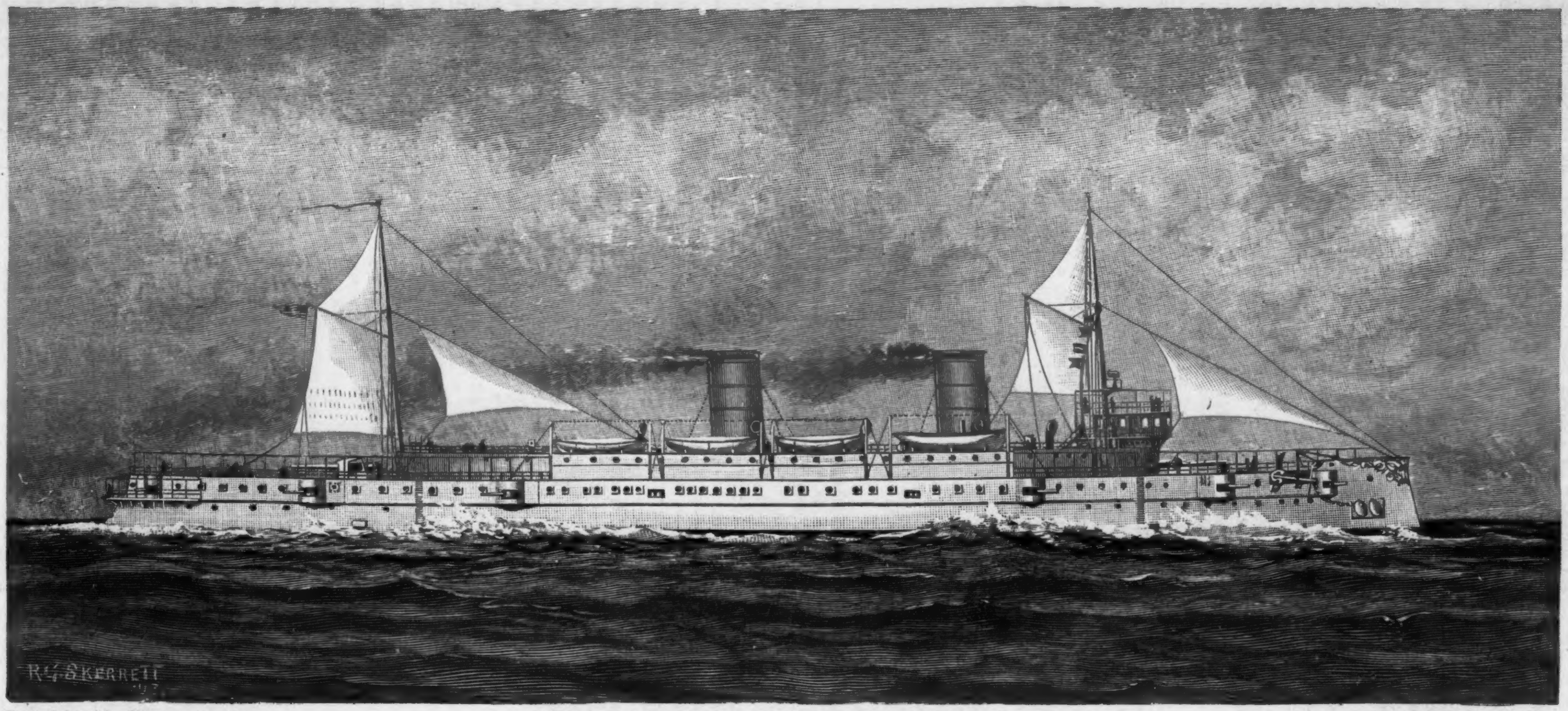
It would then be desirable to increase the projection of the thread of the spike used by the Paris, Lyons & Mediterranean Company by a small amount. They are not considering the advisibility of increasing it proportionately to the length of the ties as it has practically remained, after several years of use, and after the strains to which it is subjected scarcely more than 4.7 in.

The remarks which we have just made may appear to be somewhat theoretical, but they can at least serve as a guide to engineers who are devoting their attention by replacing spikes which are still in use by a carefully designed lag screw, where the material would be utilized in a rational way. These investigations are not without their value, for if we examine the tests made in 1875 and 1889 on the pulling power of a spike in Northern pine and in oak, we see that the improvements introduced in the ties of the screw spike and into the method of manufacture has increased their resistance about 30 per cent., or 7,640 lbs. against 5,733 lbs., and 12,844 lbs. against 9,922 lbs. in oak.

Finally, the method of fastening a flanged rail to wooden ties which we would recommend as a steel screw spike threaded hot, the pitch of whose thread is at least .5 in. for an outside diameter of .8 in., and of which the length, the diameter of the body and the projection of the thread shall be calculated so as to respectively offer a resistance to pulling proportioned to the kind of tie, and which shall be about the same as the tensile strength of the body of the spike itself. Then, this spike should be driven into a hole bored beforehand with a bit which is slightly less in diameter than that of the body of the spike. This hole could be advantageously reamed out for .08 in. or .1 in. at its upper end, in order to facilitate the entering of the body of the cylindrical portion of the spike into the wood.

THE OLDEST RAILWAY IN GERMANY.

A correspondent, Dr. Justus Jehenhäuser, of Berlin, forwards us some interesting particulars concerning the Nuremberg Fürth Railway, the pioneer iron road of the Fatherland. The line, the first link in a chain of German railways of a total length to-day of 26,000 English miles, was opened on December 7, 1835, eight months having been occupied in its construction. Although the Liverpool & Manchester and Stockton & Darlington lines were in full operation when the project of thus connecting the two Bavarian towns was first mooted, the most absurd and superstitious objections were raised against the scheme; and one circumstance that greatly disturbed the equanimity of the frugal Germans was the demand of Robert Stephenson, whose services in the capacity of consulting engineer seem to have been retained by the promoters of the railway, for a salary of £800 a year for a mechanical general manager and his interpreter. This almost proved a knock-down blow for the project; but fortunately for the company, at this critical moment a Bavarian engineer, Herr Paul Denis, appeared on the scene fresh from the United States. Terms were evidently not a great consideration with this gentleman, for he was engaged on the spot, much to the discomfiture of the Englishman, who had been anticipating quietly dropping into a good berth in the lager-beer-making State. For economy's sake, Dr. Jehenhäuser informs us, the line, between the years 1835 and 1860 was worked in the forenoon with animal power, and in the afternoon with steam engines! Until 1847, in fact, the horse trains exceeded in number the locomotive trains. But in 1860 animal traction on the railway became a thing of the past. Reverting to the salary question, it should be noted that the Nuremberg Fürth line claims the rather dubious honor of being the only railway in the world that has paid more to an engine-driver than to its manager, the last-named functionary receiving, according to the expenditure account of 1840, £100 per year, the traffic-inspector £60, and a cashier at each terminus £40; while the Englishman, a nominee of Stephenson, who attended to the iron steed, eked out a merry existence upon an annual stipend of £125. Notwithstanding the competition engendered by the construction of a tramway between Nuremberg and Fürth in 1880, the railway company has continued to flourish, and last year it paid its usual dividend of 21 per cent., the receipts having been £15,800 and the expenses, £12,200. The reserve-fund already amounts to £66,600, while the share-capital, it seems, still remains at the original figure of £8,000. The present market value of the shares, we may add in conclusion, is a trifle over £50 each.—*Iron.*



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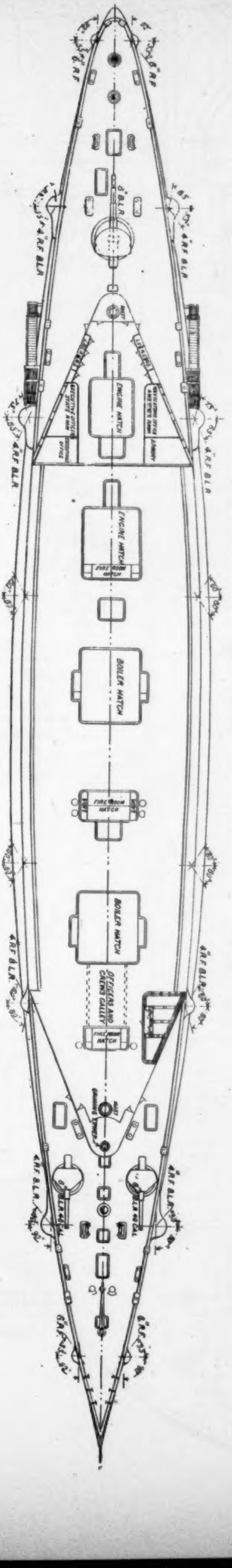
UNITED STATES CRUISER "MINNEAPOLIS."

THE United States cruiser *Minneapolis*, which is a sister ship of the *Columbia*, and has the same general appearance, with the exception of having but two smoke stacks instead of the four which the *Columbia* possesses, was launched from the Cramps' shipyard on Saturday afternoon, August 12. The vessel, which has been known in the Construction Department as Cruiser No. 13, is a commerce destroyer, and has been built in order to take the place in the United States Navy which the naval reserve in the shape of the fast transatlantic liners take in the navies of England, France and Germany. The general appearance of the vessel is very clearly given by the perspective side elevation on this page, for which we are indebted to Harper Brothers, by whom the cut has been copyrighted. The other engravings are made direct from drawings furnished by the Departments of Construction and Steam Engineering. The principal dimensions of the ship are: Length of water-line, 412 ft.; beam molded, 58 ft.; average draft with normal displacement, 26 ft. 6¼ in.; displacement, 7,350 tons. The contract speed required will be 21 knots. The vessel is built of steel, and within the outer sheathing there is the second or double bottom, which is used to guard against injuries. The intervening space is divided into water-tight compartments.

The engines, boilers and magazines are protected by a heavy steel deck and 5 ft. of patent fuel extending along the sides in the region of the water-line and throughout the locality of the vitals, protecting the machinery, etc., from machine gun fire, and at the same time forming a reserve supply in case of the exhaustion of the regular coal allowance. The engines are three in number, each of the three-cylinder vertical inverted triple-expansion type, having a collective indicated H.P. of about 22,000, driving three screws—one in the middle line, as in a single screw ship, and the others under the two counters, as in twin screw vessels. At the time of launching the central screw was in position, while the twin screws under the counters will be put in position after the vessel is dry-docked. The general arrangement and inclination of the twin screw shafts is very clearly shown by the engravings. The power is calculated to produce a speed of 21 knots an hour under the usual trial conditions, which is guaranteed by the contractors. Each engine is in a separate water-tight compartment, the engines driving the twin screws being placed abreast, the same as in twin screw ships, and the one driving the center shaft is just abaft them, lapping each for one-half its width. Steam is supplied by eight four-furnace double-ender boilers, six of which are 15 ft. 6 in. in diameter by 21 ft. 3 in. in length, and which are 14 ft. 8 in. in diameter and 18 ft. 8½ in. long, together with two single-ender two-furnace auxiliary boilers 10 ft. 1¼ in. in diameter by 8 ft. 6 in. in length. These boilers are now completed and are standing on the docks ready to be placed in position.

The full-page engraving which we present shows one-half of the largest size of these boilers. The corrugated furnaces are 3 ft. 4 in. inside diameter, with corrugations of 2 in., including the thickness of the metal. These furnaces were supplied by the Continental Iron Works of Brooklyn, N. Y.

The general construction of the boiler is clearly shown, and it is only necessary to call attention to one or two features which do not appear upon the engraving. The area through the slots which are shown in the top of the dry pipe is made equal to seven-eighths the area through the stop valve, which is



DECK PLAN OF THE UNITED STATES CRUISER "MINNEAPOLIS."

a 10-in. valve. The brass pipe is 10 in. in diameter and is made of metal No. 14 thick Birmingham wire gauge, and each course in the shell of the boiler is composed of three sheets, the metal being $1\frac{11}{32}$ in. thick. The seams are butt riveted, the butt straps being $1\frac{1}{32}$ in. thick. The rivets are so proportioned that the strength of the joint is that the plate has 84.6 per cent. of the strength of the undrilled plate, while the rivets have 89.5 per cent. of the strength of the same. The welt is riveted on with three rows of rivets. The first row stands back $2\frac{1}{16}$ in. from the edge of the plate, and is staggered with the second row, which is set back $2\frac{5}{16}$ in. from the first. The third row is staggered with the second, but has only half the number of rivets of each of the first two, and stands back $3\frac{11}{32}$ in. from the second row. All these rivets are $1\frac{5}{16}$ in. in diameter placed in holes drilled to the diameter of $1\frac{3}{8}$ in.

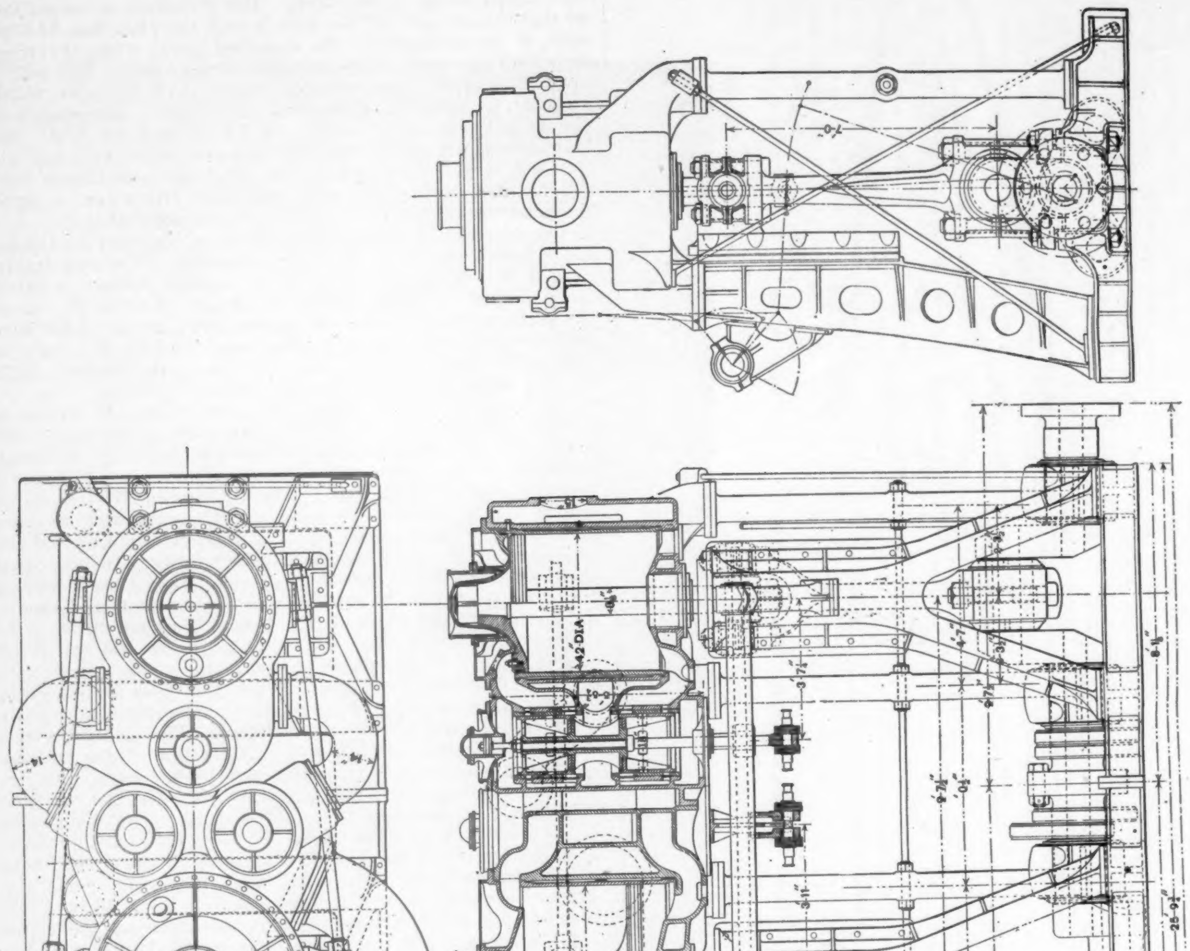
The general dimensions of the boiler are as follows: Diameter of boiler outside, 15 ft. 9 in.; diameter of furnace inside, 3 ft. 4 in.; length of grate, 7 ft.; heating surface in tubes, 5,539.5 sq. ft.; heating surface in furnace, 363.7 sq. ft.; heating surface in combustion chambers, 393.1 sq. ft.; total heating surface, 6,296.3 sq. ft.; grate area, 186.7 sq. ft.; ratio of heating surface to grate area, 33.7 to 1; calorimeter, 25.32 sq. ft.; ratio of grate area to calorimeter, 7.37 to 1.

The total number of tubes are 1,268; these are divided as follows: 316 stay tubes 6 Birmingham wire gauge thick; 952 ordinary tubes 12 Birmingham wire gauge thick. Working pressure, 160 lbs. The stay tubes are screwed into position, a practice which is followed by the Cramps in all of the large marine boilers which they construct. These tubes are screwed into both tube sheets. One end is slightly enlarged, so that the smaller end will pass through its hole readily. In order that the threads may be in unison, a special tapping bar is used in which the thread at the small end is tapped first, and then a guide thread runs through the thread thus cut in the tube sheet, and at the farther end of the bar a second tap is arranged, which is adjustable so that it will cut in unison with the thread at the small end. When the tubes are placed in position after starting at the small end the large end readily enters and the threads turn up together. The tubes are then beaded over in the ordinary way. The smaller tubes are simply put in position and expanded and beaded over. No ferrules are used; and it is stated that no difficulty has yet been experienced in keeping these tubes tight. The main stays which are shown over the top of the tubes are $2\frac{5}{8}$ in in diameter and are screwed into the outer shells at either end, and held in addition by means of a heavy nut. The man-hole at the bottom between the bottom furnaces is 11 in. × 15 in. The same size is also given to the man-hole between the right-hand furnaces. The water leg between the furnaces at the back is 7 in. wide at the bottom, tapering up to a width of 10 in. at the top. This provides for an ample and free circulation of the water in the boiler. The tubes are 7 ft. $3\frac{5}{8}$ in. long between the sheets; the location of the stay tubes is very clearly shown on the drawing, where they are shown of a thickness greater than those of the ordinary tubes. The outside diameter of all tubes is $2\frac{1}{4}$ in.

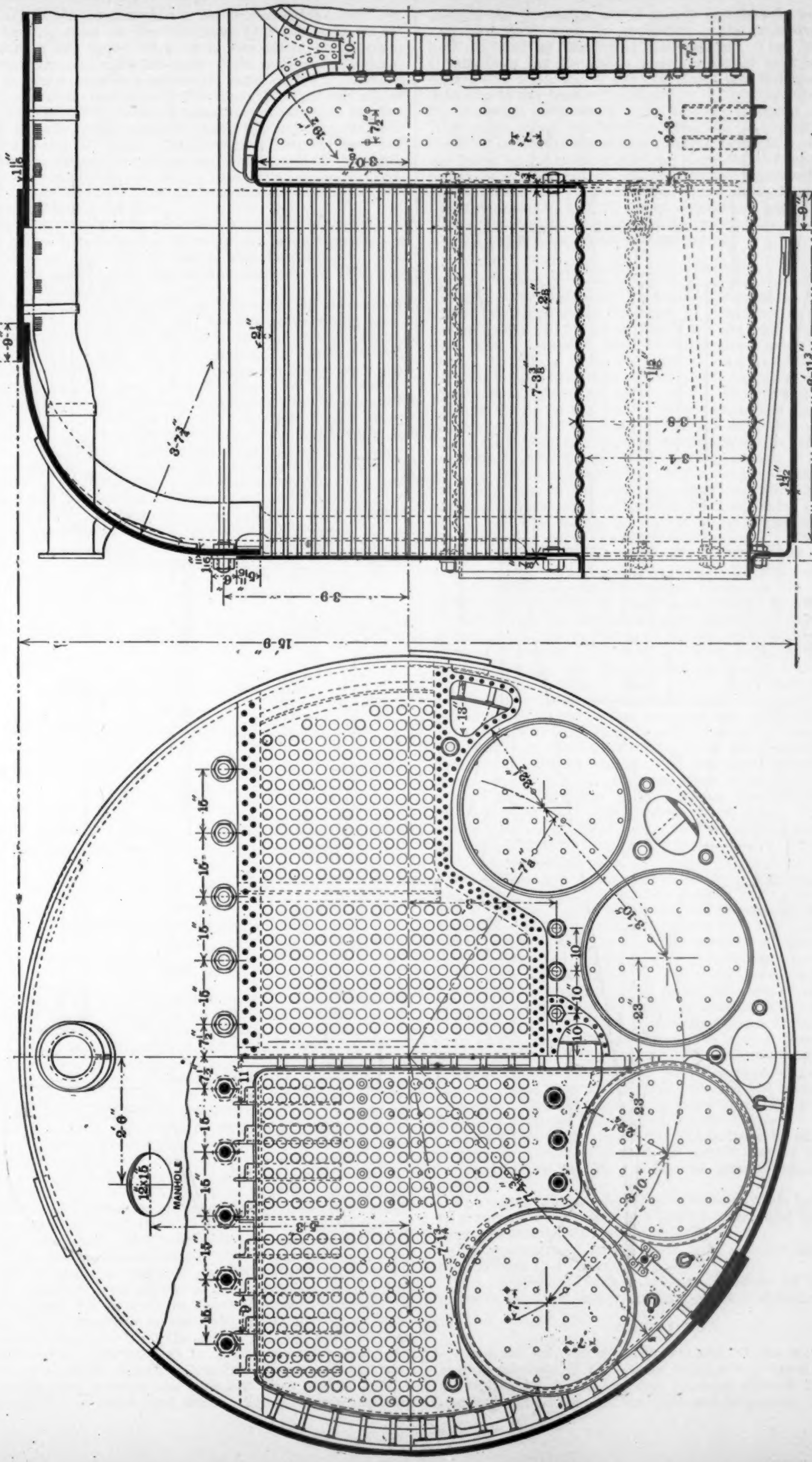
The cylinder dimensions of the engines are as follows: Diameter of high-pressure cylinder, 42 in; diameter of intermediate cylinder, 59 in.; diameter of low-pressure cylinder, 92 in., with a uniform piston stroke of 42 in. The weight of all propelling machinery, including water in the boilers, is placed at 1,950 tons.

It is unnecessary to enter very fully into the details of the engine, of which a longitudinal section is given by our engravings. Attention is called, however, to the form of the pistons and cylinder heads, and especially to the high-pressure cylinder of 42 in. in diameter shown at the right of the engravings, in which the method of reducing the clearance space at the end of the stroke is very clearly shown. The other pistons will be seen to have the same methods of reducing this space, but they are not in position to show it as clearly with the high-pressure cylinder. The valves are piston valves.

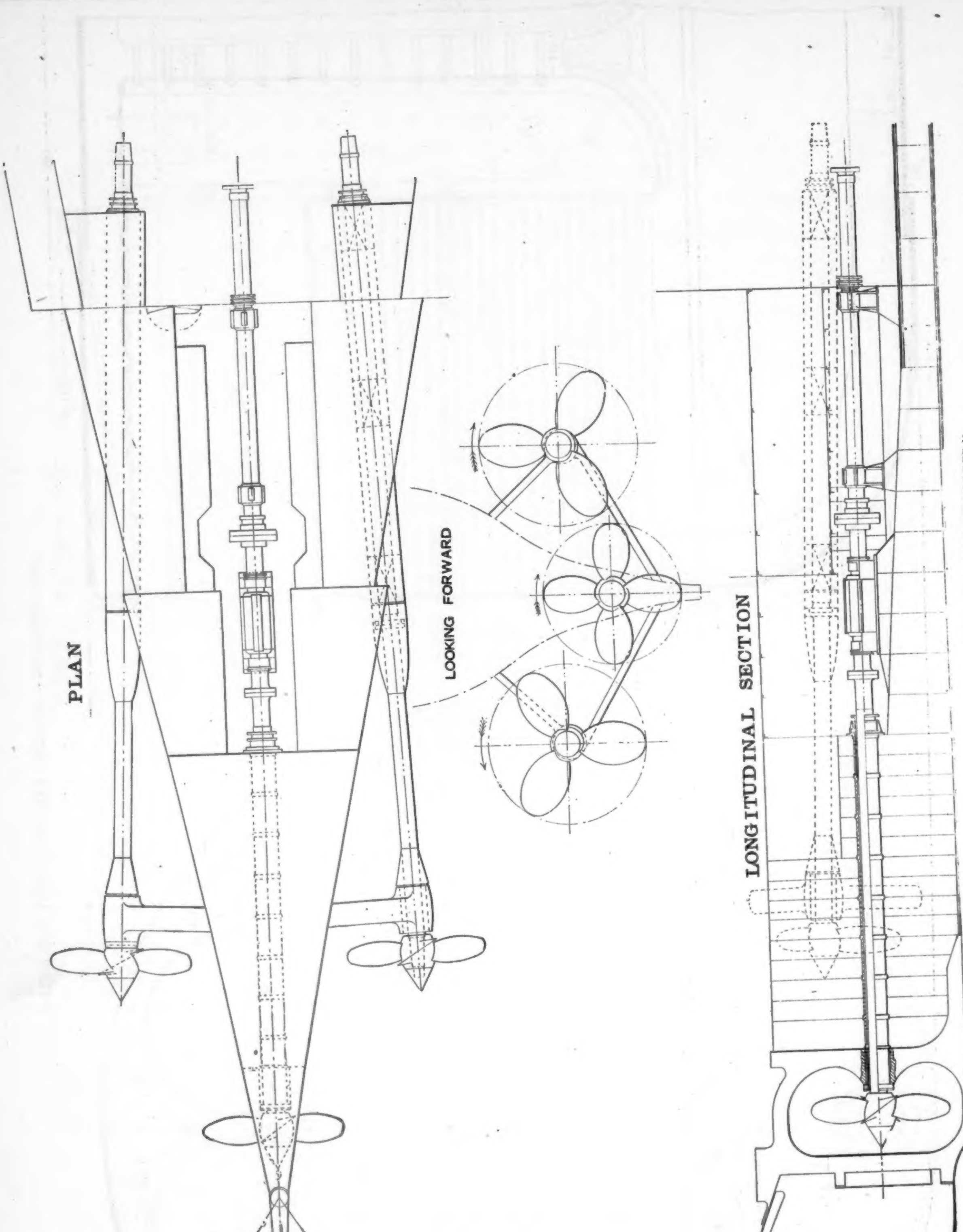
The coal supply on the normal displacement of the vessel is 1,200 tons, but there is a maximum bunker capacity of 2,200 tons, which, with an ample allowance for waste and non-effective consumption, will give the vessel, at the most economical cruising speed, a radius of action of about 16,000 knots. This is much less than the official calculation, but experience will demonstrate that it is approximately correct. The application of power through triple screws in large ships is an innovation, and its results in the *Columbia* are watched with intense interest by the entire civilized world. The *Columbia* has not yet had her trial trip, and the result of that trip will probably show about what may be expected from the *Minneapolis*. Essentially and avowedly a commerce destroyer and not a fighting ship, the armament of the *Minneapolis* is comparatively light. She carries one 8-in. breech-loading rifle of 40 calibre



STARBOARD ENGINE OF THE UNITED STATES CRUISER "MINNEAPOLIS."



BOILER FOR UNITED STATES CRUISER "MINNEAPOLIS."



SHAFTING AND PROPELLERS OF UNITED STATES CRUISER "MINNEAPOLIS."

a long aft, in the location shown on the deck plan; two 6-in. breech-loading rifles on the rapid-fire principle, with shield protection on the upper deck, as is also shown on the plan. There are eight 4-in. rapid-fire guns on the main or berth deck, with 4 in. sponsons with a horizontal range of 140°. There is a slight variation, however, in the range forward and aft of the center line. The forward guns have a range of 90° forward or directly ahead, and 50° back; the second guns have 80° forward and 60° back. The after guns have 85° back and 55° forward; the second guns have 75° back and 65° forward. This range is clearly shown on the plan. The secondary battery consists of eight six-pounders and four one-pounder rapid-fire guns and four gatlings.

As we have already said, with the exception that the *Minneapolis* has two funnels instead of four, with hawser pipes open from the upper deck, she is exactly like the *Columbia*. The contract for construction was signed August 31, 1891, the price being $6,290,000.

The ceremonies of the launching on August 12 were made an occasion for quite a gala day. It was on Saturday afternoon, when there was a half holiday in the city, and it is probable that 20,000 people witnessed the launch. The ease with which the work was performed gives one but a very poor idea of what was actually accomplished. The vessel is, of course, light, and without her boilers or machinery; but at the same time, to lower such a mass into the water quickly and safely is a task of no small magnitude. It requires about 500 men to do the work, and they were busily engaged most of the morning; but after the work of driving wedges was first begun it was probably not more than three-quarters of an hour before the vessel was in the water. After the start was made and the christening performed, the vessel was anchored in the stream in about four minutes. In a future issue we hope to give a cross section and drawings of the methods which are employed by the Cramps for launching and handling these heavy vessels.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.

Chemistry Applied to Railroads.

SECOND SERIES.—CHEMICAL METHODS.

IV.—METHOD OF DETERMINING SULPHUR IN STEEL.

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

(*Continued from page 393, Volume LXVII.*)

OPERATION.

Have ready the apparatus as shown in the cut. Weigh out 10 grams of the steel and put it into the evolution flask, which should be dry. Then put into the absorption U tube 50 c.c. of pure dilute hydrochloric acid, and connect this U tube with the evolution flask and put the bromine holder in place. Also connect the outlet of the bromine holder with the suction and then draw 5 c.c. of bromine from the holder into the U tube. Next pour 50 c.c. of distilled water through the bulb tube of the evolution flask, and start the suction a little. The displaced air passing through the U tube mixes the bromine with the liquid in the U tube. Now adjust the suction so that the column of water in the funnel tube of the evolution flask shall be about 1½ or 2 in. above the level of the water in this flask. Then add to the bulb tube of the evolution flask concentrated C. P. hydrochloric acid, at a rate sufficient to keep gas passing through the U tube, about three bubbles per second, until 100 c.c. of acid have been added. When this is done and the evolution of gas has begun to slacken a little, if the steel is not all dissolved, heat gently to assist solution, taking care not to increase the flow of gas above the prescribed rate. If solution is all complete by the time the acid is all in, or as soon as it is complete from the gentle heating, raise the temperature of the evolution flask to boiling, using the same precaution as above in regard to the flow of gas, and boil until the bubble tube between the evolution flask and U tube is about half full of condensed water. Then remove the lamp and put the permanganate of potash bubble tube in its place, and draw air through the apparatus at the prescribed rate for half an hour by increasing the suction. Then detach the U tube from the apparatus, pour the liquid in it into a 6-oz. beaker and wash the U tube carefully into the same beaker. Add also to the beaker the liquid in the bubble tube between the evolution flask and U tube, washing it out at least once. Now drive off all the bromine from the beaker by heat over the lamp or on the steam-table, taking care not to lose any of the liquid by too rapid ebullition; neutralize the acid with ammonia in very slight excess, add hydrochloric acid to faint acid reaction, and then add three drops more of concentrated hydrochloric acid and 10 c.c. of chloride of barium solution. Boil a few seconds to granulate the precipitate, filter through a small paper filter, ignite wet and weigh.

APPARATUS AND REAGENTS.

The apparatus used in this method consists, as will be observed beginning at the left hand, of a bubble tube containing permanganate of potash to purify the air used in aspirating. This tube is detached from the apparatus during the evolution. Next is a 16-oz. flask fitted with a rubber stopper, carrying a bulb tube fitted with a glass stop-cock, and holding about 100 c.c., and an outlet tube. The bulb tube should reach so nearly to the bottom of the flask that the 50 c.c. of water should seal the end, and should have the bottom end drawn out and turned up to avoid the loss of gas, which would occur if the tube is straight and borings happen to be situated directly underneath it during the evolution. Connected with the outlet tube of the evolution flask is a bubble tube which at the start contains just enough distilled water to close the end of the tube inside, the object being to prevent bromine from diffusing back into the evolution flask. The outlet of this bubble tube is connected with the absorption U tube by rubber tubing. The absorption U tube is simply an enlarged U tube with bulb-like projections blown on the top of the transverse part of the U, to serve as pockets to retain the gas a little longer in contact with the absorbing liquid. This U tube is inclined, as shown in the cut, to facilitate the movement of the gases. To avoid a rubber cork, the tube which delivers the gas into the bromine solution is fused into the top of the inlet arm of the U tube. This delivery tube is drawn out at the lower end, so as to deliver small bubbles of gas, and is arranged so that the gases issue at the lowest point of the liquid in the U tube, in order to keep the bromine mixed with the acid. The transverse part of the absorption U tube is about 10 in. long over all, and has eight bulbular projections, and the vertical parts are about 8 in. high. The exit arm of the absorption U tube carries the bromine holder, which is fitted to it with a ground-glass joint. The bromine holder consists of three parts: 1. The ground-glass stopper to connect it with the absorption U tube, which stopper is hollow and is fitted with a tubular side opening to serve as outlet for the rejected gases; 2. A bulb graduated to hold 5 c.c. for measuring the bromine, closed both at top and bottom with ground-glass cocks, and which connects between the upper cock and the graduating mark by a side tube with the top of part 3, in order to allow the measuring bulb to be filled without escape of bromine; 3. A bulb holding about 25 c.c., closed with a glass stopper at top, which serves as a reservoir for storage of bromine. The three parts are, of course, connected with each other by tubes, so that there is a passage for the bromine. The outlet for rejected gases is simply a tube over which, when the apparatus is in use, is placed a larger tube in the form of an inverted U, which does not fit, and which is connected with the suction. With the apparatus as arranged the objections to working with bromine are almost entirely removed. The whole apparatus is mounted on a single stand, with two universal clamps, and is very compact.

The pure dilute hydrochloric acid is made by adding water to the concentrated acid until the specific gravity is 1.10.

The bromine is the commercial article obtained in the market.

The permanganate of potash solution is made by dissolving 10 grams of the dry salt in a liter of water, and adding 5 c.c. of concentrated C. P. sulphuric acid.

The concentrated hydrochloric acid and the ammonia are the ordinary C. P. materials.

The chloride of barium solution is made by adding 100 grams of the C. P. salt to one liter of distilled water.

CALCULATIONS.

Since the sulphur is 13.73 per cent. of the weight of the barium sulphate, if the weight obtained expressed in grams is multiplied by 13.73, and the product divided by 100, the quotient will be the sulphur expressed in grams. Then, since

the estimation is made on 10 grams, the percentage of sulphur in the steel will be shown by removing the gram decimal point one place to the right, thus:

If the weight of barium sulphate found is 0.0572 gram, the sulphur is $\left(\frac{0.0572 \times 13.73}{100}\right) = 0.0078$ gram, and the percentage of sulphur in the steel 0.078 per cent.

NOTES AND PRECAUTIONS.

This method, as will be seen, releases the sulphur from the steel in the form of sulphuretted hydrogen, oxidizes this gas to sulphuric acid by means of bromine, and precipitates and determines this acid as barium sulphate. Duplicate determinations can be made by the method as described in from three to three and one-half hours.

The use of bromine as oxidizing agent has this advantage over most other available substances for this purpose—viz., that it enables the precipitation with chloride of barium to be done in a solution practically free from solid salts In view of the well-known tendency of barium sulphate to carry down other substances with it, this is a matter of some importance. The odor is, of course, objectionable, and it is almost impossible to get pure bromine, but these difficulties can be overcome, the former by the arrangement of the apparatus and the latter by proper allowance for the impurities.

It is essential before making a determination that not less than two blanks should be made, using all the chemicals in the prescribed amounts, and conducting the whole operation just as for a regular analysis, except that no steel is present. The weight of barium sulphate obtained as the result of these two determinations, which should not differ more than half a milligram, must be deducted from the weight of the barium sulphate obtained in the regular analysis of a steel.

It is very difficult to get bromine free from sulphates, and the C. P. hydrochloric acid of the market is also apt to be contaminated. It is accordingly recommended to set aside, for use in sulphur determinations only, a bottle of each of the chemicals used in making the blanks. Of course the figures obtained will be available as long as these bottles last.

All rubber tubes and corks used should be treated before use with a warm solution of caustic potash or soda, and after this the alkali must be completely removed by washing and the surfaces, especially the insides of the tubes, rubbed and cleaned until they present the appearance of rubber gum rather than of vulcanized rubber. Also the connections should be so made that as little as possible of the rubber tubing will be exposed to the evolved gases, by having the glass tubes at the joints touch each other inside the rubber tubing if possible.

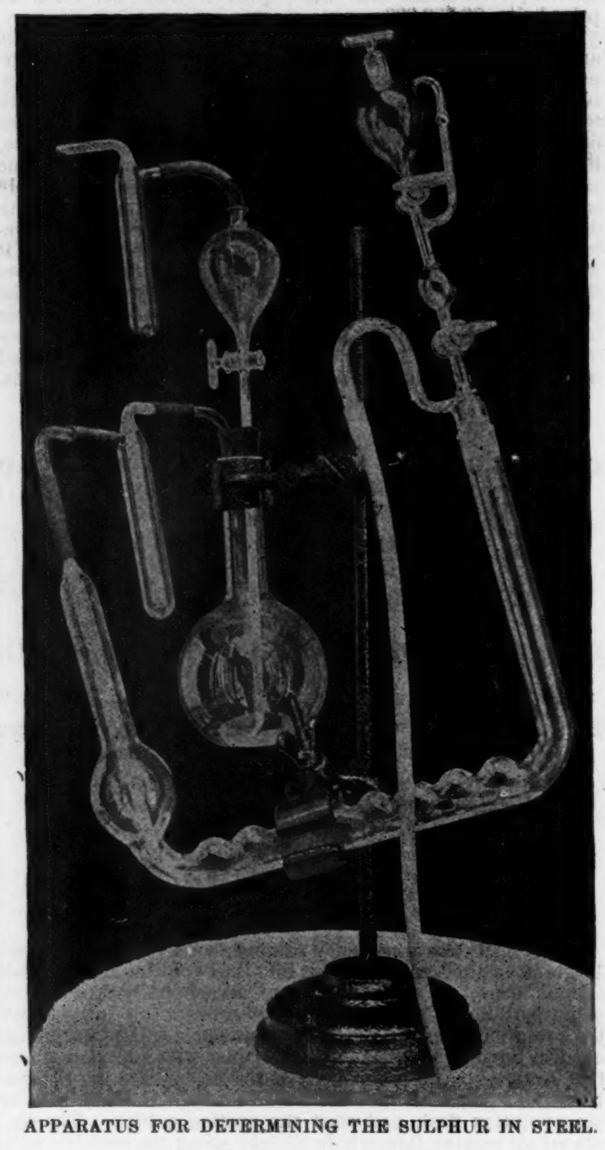
The use of a permanganate of potash bubble tube to prevent drawing sulphur gases into the apparatus along with the air used in aspiration is believed to be complete protection. Direct experiments with this solution show that both H_2S and SO_2 in air are completely retained by the permanganate of potash, even when the rate is three or four times as rapid as that specified above for the aspiration, and when the air before going into the permanganate of potash bubble tube was caused to pass through quite strong solutions of these gases in water.

Without the loose connection between the outlet for the rejected gases and the suction, it is quite difficult to regulate the rate of movement of the gases through the absorbing liquid on account of the varying rate of the escape of bromine from the solution during the operation. During the boiling to complete solution and expel the gas in the evolution flask, the rate of escape of bromine varies constantly, owing to rise in temperature. The suction being set at the beginning of the operation, if the bromine comes off a little more freely, a little less air is taken in at the loose connection and *vice versa*, so that, after the suction is once adjusted, it usually need not be changed again until the aspiration begins. We use for suction the same exhaust that is used for rapid filtration, and the bromine mixed with air that gets in through the loose connection passes away without annoyance. A large aspirator bottle filled with dilute caustic soda solution, and with inlet tube reaching nearly to the bottom, so that the rejected gases would bubble through the dilute soda solution, would be equally effective in managing rejected bromine.

It will be observed that there is no provision in the method as given for treating any sulphur compounds, which may remain undissolved in the evolution flask, as is essential in determining sulphur in pig iron. The reason for this is, that with probably 99 per cent. of commercial steels the material in the evolution flask is perfectly clear when the boiling and aspiration is finished. Furthermore, determinations on the same steel by the method given above and by the oxidation method, such as is used for pig irons, give concordant results. If the method, as described, shows a residue with any steel, the determination can hardly be regarded as satisfactory, and the oxidation method should be employed.

It is obvious that if the air of the Laboratory is contaminated with H_2S or SO_2, or even sulphuric acid fumes, from ignitions or evaporations, there will be danger of too high results from contamination of the liquid in the beaker from the two gases, while the bromine is being driven off, and at all time during the manipulation of the material in the open beaker from the sulphuric acid fumes. We have never proven how great this danger is, but it may possibly help to explain some anomalous results.

It is essential that the bulb tube through which the acid goes into the evolution flask should be left open, up to the time the permanganate of potash bubble tube is put in place, in order to prevent sucking back liquid from the absorption U tube. There is especial danger of this during the boiling.



APPARATUS FOR DETERMINING THE SULPHUR IN STEEL.

The acid may be added to the evolution flask little at a time, or may be put in the bulb tube and fed in through its glass stop-cock regularly. With some steels, and especially with coarse borings, all the acid may be put in at once and heat applied almost from the start.

When a large number of determinations are to be made at once, it is advantageous to add the barium chloride to the bromine solution in the beakers and put them on the steam table, and allow them to go to dryness; then add three drops of concentrated hydrochloric acid and about 25 c.c. of distilled water, heat nearly to boiling, filter, ignite and weigh.

Barium sulphate is liable to be reduced during the ignition of the filter, and thus lead to slightly low results. To obviate this difficulty, the filter and precipitate are put into the crucible wet, and the filter "smoked off" and then burned. The "smoking off" consists in applying the heat to the wet mate-

rial in the crucible so slowly that the volatile matter of the filter passes off without ignition, free access of air being maintained at the same time. To accomplish this, fold up the wet filter and place it in the crucible. Put the crucible on the triangle as in ordinary ignitions, and leave the cover off. Then heat the open end of the crucible slowly. The filter and precipitate gradually dry, and soon the parts of the filter in contact with the crucible begin to distill off the volatile matter at low heat, even before the whole is dry. This process goes on if the flame is properly adjusted, until in a little while everything that is volatile at a low temperature has passed away, and the precipitate, with a black envelope of carbonaceous matter, is left. When this is the case, the temperature can be raised, the lamp moved back to heat the bottom of the crucible, and the carbon burned off completely. Usually when the temperature is raised, the black envelope of carbonaceous matter falls away from the precipitate and is rapidly consumed. By this method of ignition the material is a little longer time in the crucible than with the old method of previously dried precipitates, but the danger of reducing the precipitate is believed to be very much diminished.

It is obvious that with the method, as described, no means are provided to tell whether any of the gas escapes oxidation in the bromine solution. It is believed, if the apparatus is arranged as described and the operation conducted according to the directions, no error will result. Careful comparative tests on the same steel, with the method as described, and the nitrate of silver method recommended by Fresenius, give strictly concordant results.

It will be noticed that air is used for aspiration instead of some inert gas, such as hydrogen, as is recommended by some. Comparative tests on the same steel with the method as described, and with the method modified by filling the apparatus with carbonic acid, and using the same gas for aspiration, gave exactly the same results. Carbonic acid was used instead of hydrogen as being more available.

(TO BE CONTINUED.)

PROGRESS IN FLYING MACHINES.

By O. Chanute, C.E.

(*Continued from page* 398.)

If there be one man, more than another, who deserves to succeed in flying through the air, that man is Mr. *Laurence Hargrave*, of Sydney, New South Wales. He has now constructed with his own hands no less than 18 flying machines of increasing size, all of which fly, and as a result of his many experiments (of which an account is about to be given) he now says, in a private letter to the writer, that: "I know that success is dead sure to come."

M. *Hargrave* takes out no patents for any of his aerial inventions, and he publishes from time to time full accounts of them, in order that a mutual interchange of ideas may take place with other inventors working in the same field, so as to expedite joint progress. He says: "Workers must root out the idea that by keeping the results of their labors to themselves a fortune will be assured to them. Patent fees are so much wasted money. The flying machine of the future will not be born fully fledged and capable of a flight for 1,000 miles or so. Like everything else it must be evolved gradually. The first difficulty is to get a thing that will fly at all. When this is made, a full description should be published as an aid to others. Excellence of design and workmanship will always defy competition."

M. *Hargrave* is probably correct in his reasoning, for the history of all new methods of transportation teaches that the original inventor seldom receives pecuniary reward for the contrivance which is the first to succeed, but nevertheless he is certainly broadly liberal in giving to the world gratuitously the results of his constant studies and labors. He uses exceeding care in determining the different elements which compose the flight of his models. He has carefully registered the sizes of all the parts, the power consumed in each performance, and the length of the flight, together with its trajectory. He states that he has always kept his work in such shape that it could be taken up and continued by any person at any time; so that a stranger, if an expert, could come into his shop, study his notes and drawings, pick up his tools and continue his work, and thus no portion of it would be lost.

M. *Hargrave* reports regularly the progress of his work to the Royal Society of New South Wales, of which he is a member. Thus far 12 such papers have been published, the latest having been read August 3, 1892.

He first devoted his attention to the motions performed by the propelling surfaces of birds and fishes, the waves which these created in the fluids on which they acted, and the counteraction of these waves upon the forms of the propelling surfaces themselves. The first paper, therefore, presented in August, 1884, was on the *Trochoided plane*, which M. *Hargrave* defines as "a flat surface, the center of which moves at a uniform speed in a circle, the plane being kept normal to the surface of a trochoidal wave, having a period equal to the time occupied by the center of the plane in completing one revolution." This was illustrated by working models, and the motions of wings and of fishes in swimming were artificially reproduced.

Starting from these data, M. *Hargrave* next experimented with nearly 50 models intended to reproduce horizontal flight, and in exhibiting some of these and reading his second paper, June, 1885, he said: "If the motion is not that used by birds, it is at all events very like it, and its acceptance or rejection as a scientific truth is of no further interest, as it only remains for practical mechanics to step in and adjust the details to suit the material and the motive power which they may think best for the purpose they have in view; or, in other words, that the solution of the problem of just how a bird flies is of very trifling importance from a practical standpoint, as compared with the judicious variations of the parts of the machine that will have to be made before any return can be expected for money invested in such undertakings."

Some of these models seem to have been driven by clockwork, and the motions were those of the "trochoided planes," as applied to flapping wings; then selecting the best of these models, and making their mean dimensions a standard from which to take a fresh departure, M. *Hargrave* next built a series of experimental flying machines, actuated by india-rubber in tension.

The French experimenters, as we have seen, have preferred to use rubber in torsion in order to diminish the strains upon the central spine or backbone of the model, but they thus obtained less energy per pound of weight than if they had used it in tension. M. *Hargrave* stretched the rubber so that its elongation was multiplied by pulley-tackle, and that, as the rubber contracted, its center of gravity moved forward, thus advancing the center of gravity of the entire machine, and consequently diminishing the angle of flight as the force of the rubber decreased.

No less than 10 different flying machines of various types were thus built and experimented with, all moved by rubber in tension. In the first models the cord proceeding from the rubber was wound around a cylindrical drum on the crank-shaft, but owing to the variable resistance natural to a crank-shaft, it was found better to replace the cylindrical drum by a flat winder, so adjusted on the shaft that the moment of the cord varied with the resistance of the crank, and thus communicated a more uniform movement to the wings.

Seven of these machines seem to have been propelled by flapping wings—*i.e.*, "trochoided planes"—but in order that a comparison might be made, three varieties of models were made with screw propulsion—namely, with double and with single screws in the bow, and with a single screw in the stern, which latter was concluded to be the most practicable and serviceable form.

From these experiments M. *Hargrave* concluded that the screw and the flapping wings are about equally effective as instruments of propulsion, although he rather prefers the latter, as the wings possess several marked advantages. Any currents, he says, initiated during the up-stroke are utilized in giving increased efficiency to the down-stroke, if the machine has not progressed far enough to be acting upon entirely undisturbed air. Moreover, when steam-engines come to be used, there will be only one cylinder, needed for both wings, there will be no conversion of reciprocating into rotary motion, and no variable listing moment to be counteracted, while, finally, there is less liability

that wings shall be damaged in alighting than screw blades.

Fig. 76 shows the last one (1889) of the india-rubber driven machines described by M. *Hargrave*. He calls it the "48 band-screw." The screw is at the stern, and the machine weighs exactly 2 lbs. Its sustaining area is 14.51 sq. ft. (7.26 sq. ft. per pound), and it flew 120 lineal feet with the expenditure of 196 foot-pounds of energy, while the preceding machine, weighing 2.09 lbs., with flapping wings, had flown 270 ft. with 470 foot-pounds, thus showing respectively 0.61 and 0.57 lineal feet flown per foot-pounds of power.

The framework of these machines was of pine, the larger piece (main spine) being a hollow box-girder, to secure strength and lightness. The sustaining surfaces were of paper, pasted on, and after the gum was dry rendered as tight as a drum by blowing a light spray of water over the

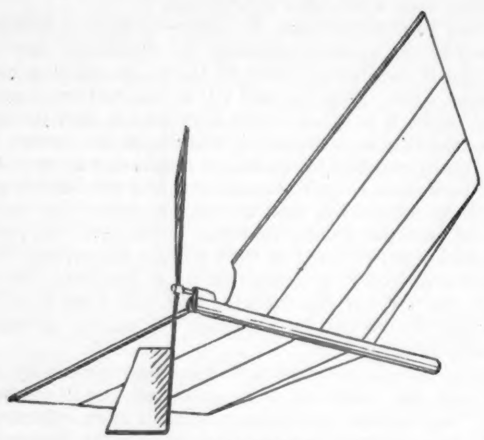


FIG. 76.—HARGRAVE—1889.

paper and allowing it to dry. Thus with small, light, simple and inexpensive models many experiments were made, and great advance realized in the distance flown over any previous experiments of others.

Having progressed thus far with india-rubber as a motive power, and gathered most valuable data and experience: as to the best arrangement and proportion of parts, the equipoise and the power required, M. *Hargrave* next undertook the construction of a flying machine actuated by compressed air, and, in 1890, he produced the machine illustrated by fig. 77, which he calls his " No. 10, 40.5 oz. compressed air," and which marked a very considerable advance in design by a great simplification of the propelling arrangement.

In presenting it to the Royal Society, June 4, 1890, M. *Hargrave* said:

The principle embodied in this experiment is that of Borelli, published in 1680, and it doubtless has had many stanch advocates in later times; but the writer maintains that this is the first practical demonstration that a machine can and does fly by the simple (vertical) flapping of wings; the feathering, tilting, twisting, trochoiding, or whatever it may be called, being solely effected by torsional stress on the wing arms.

The combination of Borelli's views with the results of work recorded in your proceedings (Royal Society) has swept away such a mass of tackle from the machine that its construction becomes a ridiculously simple matter. The engine of the model, of course, retains its precedence as the most important part, and by continuous effort the number of pieces and the difficulties of construction have been so reduced that it is possible to make them by the gross at a cost that cannot exceed five shillings each ($1.25). For instance, the cylinder, usually the most expensive portion of an engine, can be produced with the ease and celerity of a tin can. . . .

It might be said that this flying machine is not on the principle enunciated by Borelli, because the wings are not continuous from their tip to the body. But this arrangement is only a device to enable the wing tips to act on the required quantity of air with less spread; it may possibly be one of those variations which make all the difference between success and failure. These wings are also distinctly double-acting, and it is not quite clear that birds' wings thrust during the upstroke; but as previously stated, the question as to the exact movement of a bird's wing is merely straw-splitting, when we have a mechanism that actually flies and is manifestly imperfect in its present mechanical details.

This machine flew 368 ft., with the expenditure (as corrected by M. *Hargrave*) of 870 foot-pounds of energy. It weighed 2.53 lbs., and the sustaining body plane measured 14.78 sq. ft., while the two wings measured 1.50 sq. ft. in area, making a total of 16.28 sq. ft., or, say, 6.43 sq. ft. per pound.

London *Engineering*, in its issue of December 26, 1890, gives the following description of the machine:

The compressed air is stored in a tube which forms the backbone of the whole construction. This tube is 2 in. in diameter, 48¼ in. long, and has a capacity of 144.6 cub. in. Its weight is 19.5 oz., and the working pressure is 230 lbs. per square inch. The engine cylinder has a diameter of 1½ in. and a stroke of 1¼ in., while the total weight of the engine is only 6½ oz. The piston-rod is made fast to the end of the backbone, and the cylinder moves up and down over the piston. Two links connect the cylinder to the Canadian red pine rods which carry the wings. The air is admitted to the cylinder and exhausted by means of a valve worked by tappets. The period of admission continues through the entire stroke. The cylinder and receiver ends are pressed, and the piston is made of vulcanite, with a leather cup ring for packing.

The wings are made of paper, and have no canting or feathering motion other than that due to the springing of the material of which they are made. The weight of the wings is 3 oz. To find how much the wings deflected, one was held by the butt and a weight of 7½ oz. was put on the membrane 24 in. from the fixed point, and 1⅝ in. abaft the wing arm. The deflection produced, due to torsional stress, was 3½°. By moving the weight half way across the wing it was twisted 8¼°. The area of the body is 2,128 sq. in.; the area of the wings 216 sq. in., and the total area 2,344 sq. in.

When first made, the machine had its center of gravity so placed that the percentage of area in advance of it was 30 per cent. of the whole area, but continued disaster caused its reduction to 23.3 per cent. In a dead calm the machine flew 368 ft. horizontally.

It will be noted that the engine is a marvel of simplicity and lightness. Its cylinder is made like a common tin can, the cylinder covers are cut from sheet tin and pressed into shape in a vice, the piston and junk-ring are made of vulcanite, and the cup leather packing does away with the necessity for the cylinder being either round or parallel.

Beside the engine, a marked advance consisted in securing the torsion of the wings through no special mechanism, as formerly, but simply by the elasticity of the material

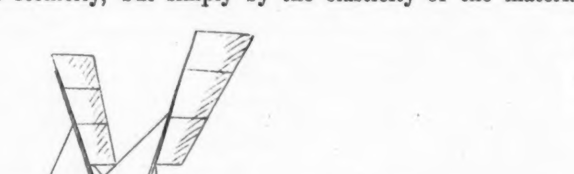


FIG. 77.—HARGRAVE, No. 10—1890.

composing them. This throws a new light upon the part performed in the flight of birds by the elasticity of their feathers, and promises great simplicity and efficiency in the future designing of artificial wings.

By looking at the figure, a bowsprit will be noticed. This was a so-called safety stick, which was added to break the fall of the machine when alighting, and it has proved quite successful in accomplishing that object.

A noticeable feature of this and subsequent machines exhibited by M. *Hargrave* consists in the extraordinary length of its supporting body plane. The same surface would carry a far greater load if it were driven broadside instead of lengthwise; but M. *Hargrave* explains that the plane was purposely so designed in order to insure longitudinal stability. This quality might also be secured by placing a tail far in the rear of a narrow supporting plane, as practiced by *Pénaud* and others. He states, moreover, that the plane

is rendered more effective per unit of surface by being cut away in the middle portion, or by being formed in two parts, separated by a gap.

As regards the lateral equilibrium, he seems to have met with but little difficulty; a slight diedral angle of the two halves of the body plane with each other providing the necessary stability, and preventing any swerving so long as the center of gravity was at all below the center of effort; but he had great trouble in working out the longitudinal stability. This he did upon the "cut and try" principle—a method doubtless the most thorough, the surest, and the most convincing, but also the most tedious. He found that the direction up or down of the machines in flight was entirely due to the distance of the center of gravity from the forward edge of the body plane, and therefore to the coincidence or otherwise of the center of gravity with the center of pressure. He measured the percentage of area in advance of the center of gravity in his three most successful machines, and found it respectively 19.3, 20 and 23.3 per cent. of the length of the plane, while subsequently he came to the general conclusion that the true position for the center of gravity for a continuous rectangular surface is situated between 0.25 and 0.2 of the length from the forward end, these positions being arrived at "by experience gained by repeated wrecks when groping in comparative darkness."

This independent working out of a complex question well illustrates the perseverance and ingenuity of this experimenter. At this juncture, however, he would have been saved much groping, time, and annoyance had he been aware of the formula of Joessël for determining the center of pressure:

$$C = (0.2 + 0.3 \sin. a) L,$$

in which C is the distance from the forward edge of a rectangular plane to its center of pressure, when inclined at the

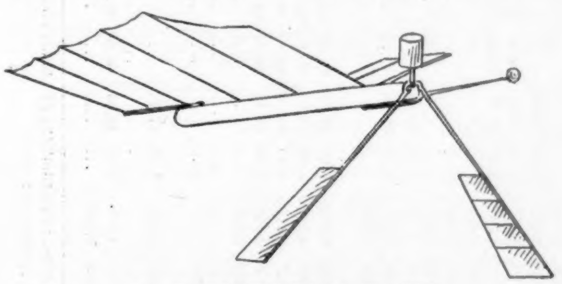


Fig. 78—HARGRAVE, No. 12.—1890.

angle of incidence a with the course, and L is the length of the plane along the line of motion.

In the same year (1890) M. *Hargrave* built another flying machine, actuated by compressed air and propelled by beating wings. This is shown by fig. 78. It was of the increased weight of 4.63 lbs., with sustaining body plane of different shape, measuring 29.63 sq. ft., or in the proportion of 6.40 sq. ft. per pound. It flew 343 ft., with an expenditure of 789 foot-pounds of energy, and therefore showed better results than the previous machine (No. 10), inasmuch as more pounds were transported on the air approximately the same distance, with a somewhat smaller expenditure of energy.

Having apparently found some advantage by shortening the body plane, M. *Hargrave* next built his flying machine No. 13, which is shown in fig. 79, with a body plane still shorter, and he provided it with a two-bladed aerial screw, set in the bow and actuated by a three-cylinder compressed-air engine of the Brotherhood type. This drove it 128 ft. in eight seconds, with an expenditure of 143 foot-pounds of energy. The apparatus weighed 46.86 oz. (2.93 lbs.), and exposed 2,952 sq. in., or 20.5 ft. of floating surface, being in the ratio of 7.00 sq. ft. per pound.

This is the first time (paper 10, July 1, 1891) that M. *Hargrave* gives us the time of flight of his machines, so that we may calculate the number of pounds of weight transported in ratio to the horse power. He says:

The time of flight is taken with a sandglass which has a loop of string at each end of it. The loop at the sand end is put round the right wrist, and the other loop is held between the right thumb and the receiver, so that the glass is turned the moment that the machine is let go. On the machine taking the ground the glass is put horizontal, and the sand which has fallen is timed at leisure. This seems an obvious enough method of finding the speed, but a practical way to do it was not devised previously.

This showed for No. 13 machine a speed of 10.34 miles per hour, which is about what we should have expected from the large proportional surface, it being about in the ratio of the slowest flying birds. This low speed M. *Hargrave* adopts on purpose, the better to observe the motions of the machines and to save breakage, and he adds quaintly that he sees no objection to this course, so long as the atmosphere is not crowded with flying machines. As No. 13 machine (fig. 79) is reported as having expended 143 foot-pounds in eight seconds, we have:

$$\text{Power} = 143 \div 8 = 18 \text{ foot-pounds per second,}$$

nearly, and, as it weighed (as reported) 2.93 lbs., we have for the weight sustained per horse power:

$$2.93 \times 550 \div 18 = 89.53 \text{ lbs. per horse power;}$$

while it will be recollected that M. *Tatin* sustained 110 lbs. per horse power and that M. *Phillips* in his recent (1893) experiments floated 72 lbs. per horse power. We will see by the analysis of subsequent performances that M. *Hargrave* did not obtain quite as good results with subsequent flying machines.

He next built his No. 14 flying machine, with much the same shape of body surface, but propelled by beating wings instead of a screw. It weighed 3.69 lbs. and exposed 22.84 sq. ft. of surface, being in the proportion of 6.19 sq. ft. per pound. It flew 312 ft. in 19 seconds, with an expenditure of 509 foot-pounds, and thus we have:

$$\text{Power} = 509 \div 19 = 26.79 \text{ foot-pounds per second,}$$

and for the weight floated per horse power:

$$3.69 \times 550 \div 26.79 = 75.75 \text{ lbs. per horse power.}$$

This apparatus (No. 14) M. *Hargrave* has generously offered to present to some American institution which will take proper care of it, believing it to be one in which "the increased skill in construction acquired by practice is thought to have resulted in an apparatus that, for its weight, it will be hard to excel." He says in his paper to the Royal Society:

It may be said that it is a waste of time to make machines of such small capabilities, and that no practical good can come of them. But we must not try too much at first; we must remember that all our inventions are but developments of crude ideas; that a commercially successful result in a practically unexplored field cannot possibly be got without an enormous amount of unremunerative work. It is the piled-up and recorded experience of many busy brains that has produced the luxurious travelling conveniences of to-day, which in no way astonish us, and there is no good reason for supposing that we shall always be content to keep on the agitated surface of the sea and air, when it is possible to travel in a superior plane, unimpeded by frictional disturbances.

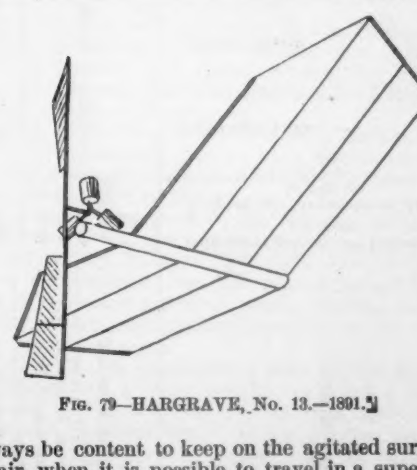


Fig. 79—HARGRAVE, No. 13.—1891.

No. 16 was another compressed-air flying machine with beating wings and somewhat differently shaped body plane. It weighed 4.66 lbs., spread 26.06 sq. ft. of surface, and

LOCOMOTIVE RETURNS FOR THE MONTH OF MAY, 1893.

Name of Road.	Number of Serviceable Locomotives on Road	Number of Locomotives Actually in Service.	Locomotive Mileage. Passenger Trains.	Locomotive Mileage. Freight Trains	Locomotive Mileage. Service and Switching.	Locomotive Mileage. Total.	Locomotive Mileage. Average per Engine.	Av. Train. Passenger Cars.	Av. Train. Freight Cars.	Coal Burned per Mile. Passenger Train Mile.	Coal Burned per Mile. Freight Train Mile.	Coal Burned per Mile. Service and Switching Mile.	Coal Burned per Mile. Train Mile, all Service.	Coal Burned per Mile. Passenger Car Mile.	Coal Burned per Mile. Freight Car Mile.	Cost per Locomotive Mile. Repairs.	Cost per Locomotive Mile. Fuel.	Cost per Locomotive Mile. Oil, Tallow and Waste.	Cost per Locomotive Mile. Other Accounts.	Cost per Locomotive Mile. Engineers and Firemen.	Cost per Locomotive Mile. Wiping, etc.	Cost per Locomotive Mile. Total.	Cost per Car Mile. Passenger.	Cost per Car Mile. Freight.	Cost of Coal per Ton.
										Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	$
Atchison, Topeka & Santa Fé	834	722	...	...	372,043	2,408,566	3,336	...	...	...	...	...	71.05	...	...	3.84	5.85	0.29	0.13	6.88	1.01	18.10	...	...	1.58
Canadian Pacific	612	...	513,921	737,933	438,052	1,689,806	2,761	...	...	...	...	...	65.12	...	...	4.07	10.50	0.34	...	5.69	1.42	22.02	...	...	3.21
Chic., Burlington & Quincy	542	...	...	...	...	1,759,662	3,265	5.23	18.04	...	...	...	83.36	...	...	4.74	5.50	0.24	0.18	6.92	0.07	17.71	...	...	1.33
Chic., Milwaukee & St. Paul	827	...	...	...	...	2,473,555	2,990	...	...	...	...	...	70.59	...	...	4.54	7.44	0.28	...	6.90	...	19.16	...	...	2.05
Chic., Rock Island & Pacific	564	...	616,453	933,108	448,136	1,997,697	3,542	...	...	58.08	78.67	41.23	64.06	...	...	5.70	5.96	0.27	...	5.95	0.41	15.44	...	...	2.00
Chicago & Northwestern	888	...	751,263	1,355,559	709,780	2,816,602	3,171	...	...	...	...	...	83.15	...	...	3.76	7.40	0.36	...	6.36	0.87	18.75	...	...	1.76
Cincinnati Southern	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cumberland & Penn.*	...	24	5,361	29,583	...	34,944	1,456	...	...	...	...	...	93.89	...	...	7.20	5.10	0.43	...	...	2.05	14.78	...	...	...
Delaware, Lackawanna & W. Main L.	210	191	66,970	206,955	449,380	723,305	3,787	...	...	...	...	...	85.57	...	...	3.22	6.65	0.47	...	5.75	...	16.09	...	...	1.57
Morris & Essex Division	160	...	176,796	159,952	99,610	436,358	2,727	...	...	...	...	...	59.22	...	...	4.50	9.29	0.43	...	6.23	...	20.45	...	...	3.11
Hannibal & St. Joseph	...	74	...	...	...	260,796	3,780	5.52	16.67	...	...	...	82.74	14.05	6.19	2.50	5.59	0.13	0.26	6.88	0.08	15.39	...	...	1.28
Kansas City, F. S. & Memphis	143	...	102,133	222,385	106,088	430,606	3,011	...	...	...	...	...	59.52	...	...	4.32	5.13	0.24	0.37	7.45	...	17.51	...	...	1.68
Kan. City, Mem. & Birm	42	38	36,793	42,401	16,306	95,500	2,513	...	...	...	...	...	61.10	...	...	4.27	3.24	0.24	0.36	7.16	...	15.27	...	...	1.01
Kan. City, St. Jo. & Council Bluffs	...	38	...	...	...	140,048	3,685	5.03	20.64	...	...	...	63.69	13.13	4.45	2.63	5.73	0.14	0.21	6.20	0.08	14.94	...	...	1.91
Lake Shore & Mich. Southern	587	...	458,536	788,765	480,740	1,828,041	3,114	...	...	60.08	84.24	39.56	62.93	...	...	3.14	4.93	0.06	0.13	6.96	0.19	15.41	...	...	2.01
Louisville & Nashville	...	338	454,319	797,140	434,879	1,687,338	3,625	5.13	15.99	61.64	106.55	47.97	78.65	12.14	6.14	4.55	6.32	0.27	1.32	6.08	0.61	19.15	3.41	1.51	1.66
Manhattan Elevated	...	295	796,169	...	60,815	856,984	2,905	...	...	...	...	...	43.95	...	...	2.90	8.90	0.20	...	8.90	...	20.90	...	...	4.03
Mexican Central	148	114	...	...	...	414,608	3,639	...	...	...	...	...	70.42	...	...	5.13	14.54	0.53	0.23	5.27	0.81	26.51	...	...	4.46
Mil., L. S. & Western	112	...	79,282	143,745	67,299	300,326	2,681	...	...	...	...	...	72.07	...	...	3.38	10.01	0.16	...	6.16	0.92	20.63	...	...	2.80
Minn., St. Paul & Sault Ste. Marie	...	...	65,065	156,620	68,365	290,050	...	5.28	18.64	...	...	...	68.75	...	...	4.40	11.80	0.28	...	6.46	...	22.94	...	...	3.42
Missouri Pacific	338	...	...	...	...	1,146,963	3,483	4.35	16.35	...	...	...	81.93	...	...	5.57	5.78	0.32	1.31	6.35	1.32	20.65	4.12	1.58	1.43
Mobile & Ohio	107	83	64,941	174,108	63,904	802,953	3,650	...	...	...	...	...	65.21	...	...	2.57	4.69	0.22	0.58	5.78	0.87	14.71	...	...	1.43
N. O. and Northwestern	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
N. Y., Lake Erie & Western	613	407	464,994	859,953	288,735	1,613,682	3,964	4.60	22.50	87.30	133.50	68.75	...	18.90	5.90	5.07	8.06	0.89	2.22	7.27	1.17	24.18	...	...	1.50
N. Y., Pennsylvania & Ohio	256	170	139,004	423,248	159,007	721,259	4,242	5.60	18.20	58.60	124.80	77.45	...	10.40	6.90	3.32	5.61	0.31	2.33	6.87	0.97	19.40	...	...	1.12
Norfolk & Western, Gen. East. Div.†	...	...	118,194	333,204	58,329	509,727	2,913	4.70	20.70	46.29	119.76	...	...	9.80	5.80	3.40	3.90	0.70	...	...	...	8.00	...	...	...
General Western Division†	...	...	108,053	302,257	45,510	455,820	2,532	5.40	17.10	69.00	125.00	...	115.00	13.26	7.98	6.71	4.29	0.51	...	...	...	11.51	...	...	...
Ohio and Mississippi	115	...	149,207	138,027	97,028	384,262	3,341	...	...	...	...	...	72.72	...	...	3.32	2.77	0.23	1.20	5.33	1.56	14.41	...	...	0.73
Old Colony	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Philadelphia & Reading	...	...	485,410	344,715	1,020,178	1,850,303	...	...	...	...	...	...	81.63	...	...	4.98	6.02	0.35	...	5.92	0.42	17.69	...	...	...
Southern Pacific, Pacific System	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Union Pacific	992	...	715,833	1,392,938	470,632	2,579,403	3,332	5.84	17.16	...	...	...	95.51	...	...	7.24	9.83	0.41	0.89	7.98	1.18	27.48	4.39	2.00	2.05
Vicksburg, S. & P.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Wabash	426	351	422,300	682,901	201,309	1,406,510	4,007	5.07	16.34	69.30	97.41	52.03	78.95	13.65	5.95	3.48	4.05	0.28	...	6.23	0.85	14.89	2.48	1.06	1.05
Wisconsin Central	153	122	129,702	203,087	73,249	406,938	3,328	...	...	...	...	...	80.97	...	...	3.29	8.34	0.22	...	6.92	...	18.77	...	...	2.03

NOTE.—In giving average mileage, coal burned per mile and cost per mile for freight cars, all calculations are made on the basis of *loaded* cars.

* Switching engines allowed 6 miles per hour; wood, construction and gravel trains, 10 miles per hour.

† Wages of engineers and firemen not included in cost.

flew 343 ft. in 23 seconds, with an expenditure of 742 foot-pounds. The power was therefore:

Power = 742 ÷ 23 = 32.26 foot-pounds per second,

and the weight floated per horse power:

4.66 × 550 ÷ 32.28 = 79.45 lbs. per horse power.

Several forms of body plane seem to have been tested in this machine and no less than 12 trials were recorded, trial No. 10 being the successful one, from which the above data have been taken.

Having now constructed ten flying machines of different types and proportions actuated by india-rubber in tension, and six actuated by compressed air, of increasing size and weight, M. *Hargrave* then turned his attention to producing a steam motor which should equal in lightness and surpass in power the best compressed-air motors thus far constructed by him, and which should furnish driving power for a longer time.

But first he endeavored to work out an idea which he seems to have entertained for some years, of testing an explosion motor. His engine No. 15 consisted of a turbine to be worked by the gases resulting from the explosion of a mixture of nitrate of ammonia, charcoal, and sulphur; but a considerable expenditure of time only resulted in a failure.

He also experimented upon a method of utilizing sea waves in propelling vessels, which he believes to be the germ of the solution of the soaring problem, and he succeeded in securing such automatic action that a 12½ lb. model advanced in the wind's eye at five-eighths of a mile per hour.

He also made some experiments upon pure aluminium, but found that it presented no advantages for flying-machine construction.

(TO BE CONTINUED.)

ACCIDENTS TO LOCOMOTIVE ENGINEERS AND FIREMEN.

THE object of publishing this monthly list of accidents to locomotive engineers and firemen is to make known the terrible sacrifice of life and limb that is constantly going on among this class of people, with the hope that such publication will in time indicate some of the causes of accidents of this kind, and help to lessen the awful amount of suffering due directly and indirectly to them. If any one will aid us with information which will help to make our list more complete or correct, or who will indicate the causes or the cures for any kind of accidents which occur, they will not only be doing us a favor, but will be aiding in accomplishing the object of publishing this report, which is to lessen the risk and danger to which the men to whom we all intrust our lives are exposed.

The only, or the chief source of information we have, from which our report is made up, is the newspapers. From these the following list of accidents, which occurred in July, has been made up. Of course we cannot report those of which we have no knowledge, and doubtless there are many such.

ACCIDENTS FOR JULY.

Rowaton, Conn., July 1.—The cylinder-head of a locomotive hauling a train on the New York, New Haven & Hartford Road blew out this morning, severely scalding the fireman and delaying traffic for several hours. The fireman was taken to a hotel, where his wounds were attended to.

Wheeling, W. Va., July 4.—An accommodation train on the Panhandle Road was derailed this morning south of Wellsburg. The fireman of the engine, Simon Cussick, of Steubenville, O., was killed. Several passengers were injured. Spreading of the rails caused the disaster. The engine and two coaches were derailed and overturned.

Erie, Pa., July 8.—A head-end collision occurred between Philadelphia and Erie freight trains Nos. 65 and 62, near Johnsonburg, this morning. The west-bound train, No. 65, passed Ridgeway without orders. Engineer John Bradlock, of Renovo, on the east-bound special, was killed at his post. Fireman Keppler was also badly crushed and will die. Engineer J. Robinson, of the west bound train, and William Schoeffer, fireman, are severely injured.

Roanoke, Va., July 8.—William S. Arkins, fireman on the east-bound vestibule of the Norfolk & Western Railroad, fell from his engine this evening and was badly hurt.

Menominee, Mich., July 8.—In a wreck at Bagley to-night Engineer Berrington and Fireman Dolan were fatally injured.

Wilkesbarre, Pa., July 10.—James Finney, of Wilkesbarre, a fireman, was slightly hurt at Coxton to-night, by passenger train No. 17 on the Lehigh Valley Road running into a freight train.

Dover, N. H., July 11.—An extra train on the Boston & Maine Railroad collided with a freight car, which had backed off the Y at Rollingsford. Frank Down, engineer, and Forrest Carrish jumped. Carrish broke his neck, but was taken up alive and sent to Rochester, where no thoughts of his recovery are entertained.

Avon, N. Y., July 11.—Fred J. Barnard, a fireman on a way freight, fell from his engine when just out of Attica to-night and fractured his wrist.

Columbus, Ind., July 13.—A special freight train ran into a regular freight at Henryville, Ind., south of here to-night. George Sherley and Brook Bank, engineer and fireman of the special, were fatally hurt.

Chicago, Ill., July 14.—A Baltimore & Ohio suburban train was ditched at Eighty-seventh Street this morning. An open switch caused the accident. Engineer John Houlihan was scalded and painfully injured, but not fatally.

Radford, Va., July 15.—A collision on the new river division of the Norfolk & Western Road occurred to-day. Fireman Pool was killed, and Engineer Ransom badly scalded. Engineer Monroe had both ankles sprained and was hurt internally.

Pittsburg, Pa., July 15.—At four o'clock this morning engine No. 139, drawing the east-bound freight on the Pittsburg & Western Railway, ran into a mass of stone at the mouth of tunnel No. 1, near Undercliffe Station, completely wrecking the engine and six cars. Fireman John O'Neill and Engineer Charles Angell both sustained injuries in the accident, but not of a serious nature. The cause was the falling of the roof of the tunnel just as the train approached.

College Point, N. Y., July 17.—James Walsh slipped from the tank of his engine on the Central Hudson Road this morning, and fell to the ground, striking upon a large piece of coal, breaking two of the upper ribs on the left side.

Zanesville, O., July 18.—W. H. Core, an engineer on the Baltimore & Ohio Road, injured his right elbow by striking it against the backboard of his engine to-day.

Buffalo, N. Y., July 18.—An excursion train on the Western New York & Pennsylvania Railway ran into a turn table pit at East Aurora to-night. There was a sharp curve and down grade just above the station, and the engineer was unable to see that the switch leading to the table was open. Fireman John N. Norris received a concussion of the brain and a heavy cut over the left eye.

Scranton, Pa., July 18.—Matthew Whalen, of Great Bend, a fireman on the Delaware, Lackawanna & Western Railroad, was leaning out of the cab window this evening and lost his balance, falling to the ground. He was removed to the hospital, where it was found that several of his ribs were broken and that he had sustained internal injuries.

New London, Conn., July 19.—James Raleigh, fireman on the New London & Northern Railway, while turning an engine on the turn-table at Union Station, Norwich, this evening, caught his right forefinger between the turn-table lever and a car on the switch, badly crushing the finger.

Joliet, Ill., July 20.—A Rock Island & Pacific stock train ran into a side-tracked train at Tiskilwa this afternoon. George Hickey, fireman, and Henry Strong, the engineer, were killed. The flagman had been sent back, and states that Strong paid no attention to his signals.

Jackson, Mich., July 21.—Will Westfall, a fireman on the Michigan Central Road, was scalded by a stream of hot oil near Albion this evening. The glass of the lubricator burst, and three streams of oil were thrown out. One barely missed the engineer, another one went to the left side of the cab, while a third shot down upon Westfall just as he put the scoopful of coal in the fire box. The right side of the face and neck were badly burned; the skin was pulled off, leaving the bare flesh, from which the blood oozed trickling down his clothing. The young man suffered terribly on his way to Jackson.

Anna, Ill., July 21.—A south-bound train on the Mobile & Ohio Railroad ran into a loose freight car 2 miles west of Jonesburg to-day. The fireman, Joe Sammis, received internal injuries, and Engineer Ben Ward had his foot injured.

Cleveland, O., July 22.—An engine drawing three cars jumped the track in the Alabama Street yards early this morning. Engineer John H. Hines and his fireman leaped from the engine. The latter escaped, but Hines took the wrong side of the engine, and it toppled over on him. He was crushed and burned in a horrible manner, and was dead when extricated.

Danville, Ill., July 23.—William Burns, an engineer on the C. V. & C. Road, had his leg broken and head gashed in a rear-end collision at Lawrenceburg this morning. Burns was pulling the second section, and the first had stopped at Lawrenceburg for water, when Burns, thinking they had proceeded, came on. The collision occurred when the second section was moving at the rate of about 2 miles an hour, but Burns jumped and received the injuries specified.

Pittsburg, Pa., July 25.—An accommodation train on the Alleghany Road collided with a freight train at Willow Grove Station this morning. The accident occurred on a curve where the engineer of the approaching train was unable to see the freight train until too near to stop. Frank Stump, the fireman, jumped from the engine, and escaped with a few bruises. Engineer Albert Bissell stood at his post, and when taken out was found to have sustained only a few scratches and bruises, which will not prove serious.

Morgansville, Ky., July 25.—A freight train on the Ohio Valley Road was ditched 2 miles west of here early this morning. Robert Van Dorn, engineer, and Frank Threlkeld, the fireman, were killed and their bodies burnt to a crisp.

Warwick, N. Y., July 25.—Fireman Blake fell from his engine on the New York, Lehigh & Hudson Railroad near Maybrook to-night, and was seriously injured about the head.

Buffalo, N. Y., July 25.—Levi Snyder, a fireman on the Western New York & Pennsylvania Road, was badly injured this morning by a passenger train. He was tossed into the air and struck head-foremost upon the rails. When examined it was found that his skull was fractured, and he was otherwise badly bruised about the body and head.

Delaware, O., July 25.—In consequence of a misplaced switch a heavy coal train collided with a switch engine in the Hocking Valley yard at this place to-day. Engineer Brown, of the switcher, was terribly bruised and lacerated about the hands and face.

Nashville, Tenn., July 26.—Four cars loaded with logs became detached from a freight train about 70 miles south of here this morning, and ran back down a long grade into an express. Fireman Joe Zeanone was injured, but not fatally.

Wilkesbarre, Pa., July 27.—The Cannon-Ball freight train, on the Lehigh Valley Road, ran into a pusher at Gracedale this morning. The Cannon-Ball had two engines, one in front and one at the rear. Engineer George Hapeman, of the second engine, jumped and landed on a bank of dirt, rebounded against the engine, and sustained a severe scalp wound and bruises on his back. Martin Ryan, the fireman, had his arm badly hurt.

Pueblo, Col., July 27.—A cloud burst on the south side of Pike's Peak this morning, flooding the Arkansas River, by which the trestle on the Union Pacific Railroad, a mile from the city, was weakened, and a freight train plunged to the bottom of the cañon. Engineer Henderson lies under the engine, and Fireman Nye is fatally injured.

Reading, Pa., July 28.—A coal train pulling over the grade to Spring Mills on the Schuylkill Valley branch of the Pennsylvania Road broke in two this evening. Another freight train crashed into it. The locomotive was derailed and turned about. The engineer escaped injury by jumping, but the fireman, Frank Farrel, received a painful cut on the leg while attempting to stop the engine.

Indianapolis, Ind., July 28.—A passenger train on the Pittsburg, Cincinnati, Chicago & St. Louis Railroad collided with a freight train just north of this city on the Lake Erie & Western tracks. The collision was a head-on one. Al Woods, passenger engineer, had his ankle broken and face hurt. Walter Ensey, passenger fireman, had his face and head badly injured.

Springfield, Ont., July 29.—An express on the Michigan Central Road was derailed here this afternoon. The engineer was badly scalded.

Fort Worth, Tex., July 30.—Harry Lyons, an engineer at Celina, was terribly scalded to-day by the blowing out of a safety-valve.

Wilkesbarre, Pa., July 31.—An empty engine on the Delano Division of the Lehigh Valley Railroad ran into a passenger train near Mahanoy City to-day. Engineer Miner, of the passenger train, was injured about the head. Both engines were wrecked.

Our report for July, it will be seen, includes 35 accidents, in which seven engineers and nine firemen were killed, and 15 engineers and 19 firemen injured. The causes of the accidents may be classified as follows:

Blowing out of cylinder head	1
" " " safety-valve	1
Bursting of oil glass	1
Collisions	13
Derailments	4
Falling from engine	5
Misplaced switch	4
Striking against cab	1
Unknown	1
Tunnel roof falling	1
Struck against backboard	1
Turning engine	1
Struck by passing train	1
Washout	1
	36

GENERAL MARINE NOTES.

Largest Dredge in the World.—A trial was recently made of a large dredge built for deepening the bar at the mouth of the Mersey River. It is estimated that it will raise 24,000 tons of matter daily.

An Aluminum Cutter.—A 10-ton cutter constructed of aluminum, said to be the first sea-going vessel made of this metal, is being built at Loire, for Comte de Chabannes la Pollice. It will be half the weight of a vessel of similar class constructed with a steel frame. Her hull will weigh only 5,500 lbs., whereas, if built of the ordinary material, it would weigh 10,000 lbs.

The Battleship "Resolution."—The battleship *Resolution*, which has recently been completed on the Tyne, will take the place of the *Victoria*, which was recently lost. The new vessel is one of the largest battleships afloat, comprising one of the eight built under the Naval Defence Act of 1889. She is 40 ft. longer, 5 ft. broader, and has 3,680 tons more displacement than the *Victoria*. When used as a flagship she will have a complement of over 700 officers and men.

Air Sacks for Wrecking.—Air sacks have recently been successfully used for raising wrecks on the Pacific coast. The method consists of placing canvas sacks 20 ft. × 4½ ft. in the hold. Each of these sacks is attached by a hose to a powerful air-pump. The sacks are adjusted by a diver and are then inflated. Water is forced out of the hull, the inflated sacks taking its place and then acting as pontoons for raising the vessel.

A Bow Rudder.—The new steel side-wheel steamer *City of Alpena*, which was built at Detroit, is provided with a bow rudder that is used in moving the boat about the harbor. There are two wheels in the wheel-house, one operating the bow rudder by hand and the other connected with the steam steering-gear for the ordinary rudder. Considerable interest is manifested in the device among the vesselmen, and it is said to be working well.

The Largest Freight Steamer in the World.—A steamer which is claimed to be the largest freight steamer in the world has recently been launched at Dunbarton in Scotland. Her displacement is about 15,000 tons, and she will carry 7,000 tons of freight. In addition to freight she will have a capacity for 300 second-class and 1,200 third-class passengers, but no first-class. She is intended for traffic between Liverpool and Philadelphia, and is intended to make the distance between these two points in eight days.

Trolley System for Boats on the Colorado River.—We have noticed the fact that a trolley system of boat propulsion is to be tested on the Erie Canal, and recent advices from Colorado state that an investigation is being made as to the feasibility of using a trolley line for operating small boats through the Black Cañon and other scenic points. The power is to be generated by water-wheels driven by the current of the river. One of the features of the scheme is to convey the surplus portion of the power down the river, where it will be used for pumping the water of the river to a height of from 15 ft. to 20 ft. upon mesa lands for irrigation.

A New Idea in Ship-building.—The Boston *Journal* states that a new idea in ship-building has been developed at Belfast. There is a vessel on the stocks there which has no keel for about 120 ft. from the sternpost, while 6 ft. of the sternpost is cut away, the hull of the vessel sloping from the horizontal for the 120 ft. until level with the curtailed sternpost. The bottom of the sternpost and the actual stern of the vessel are not connected in any way. The vessel is a twin screw, and the propellers will work through a small aperture, with nothing between them and the water beneath. They will, therefore, always be in unbroken water.

Blowing up Derelicts.—A dispatch from Washington states that there is a probability of an agreement being made between England and the United States for blowing up the ocean derelicts. The proposition is that England and the United States shall each assign two warships of the cruiser type suited to this work, for the duty of keeping the tracks of ships and steamers in the North Atlantic clear of derelicts. The English ships will look after the wrecks on the adopted Transatlantic routes north, while the American ships will destroy the wrecks of the ocean farther south and along the coast between New York and Hatteras.

A Magnetized Towing Drum.—A novel application of electricity in the canal service has been made in France on the canals on which the endless chain system of towing is in vogue. The chain lies in the bottom of the canal, and is brought over the bows of the boats, carried around drums, and then passed over the stern into the water. In order to make the chain cling to the drums it has been necessary to pass it around them a number of times. This produces a heavy tension that results in frequent breaking of the chain. A drum magnetized with electricity has now been invented which holds the chain firmly and obviates the necessity of numerous turns.

A Kite to Send Life-lines Ashore.—Professor G. Woodbridge Davis has just concluded an interesting series of experiments with kites as a means of sending life-lines ashore at Newport, L. I. He went on board Brenton Reef lightship and remained there four days, and made the ship his headquarters for the experiments. He made several trials, but was unable to get suitable wind to land his kite on Brenton Reef, which is about 1¼ miles from the lightship. Failing to get a wind blowing on shore, Davis sent a kite out with a 32-lb. buoy as a drag. This was a success, and the five men engaged to haul the kite in declared the kite was not wet. The buoy was attached to a rope about 200 ft. from the kite, allowing the flying machine to float at that distance from the water.

A New Steamer for Fall River Line.—The new 4,000-ton steamer for the Fall River Line was recently launched at the old Roach shipyard, and was towed to New York the next day for the purpose of receiving her machinery. The new boat is 420 ft. on the water-line and 440 ft. over all, or 20 ft. longer than the *Puritan*. Her hull is 52 ft. 6 in. wide, and her extreme breadth over guards is 93 ft. The draft will be 12 ft. 6 in., and she has a total displacement of 4,550 tons. She was designed by George Pierce, Supervisor of the Fall River Line. Her outward appearance is similar to that of the *Puritan*. She has two steel masts and two smoke-stacks. Her passenger and freight capacity will be even greater than the *Puritan*, and she will be more elaborately finished and furnished. It is expected that she will be ready for service early next summer.

The British Mercantile Marine.—The total number of vessels in the British mercantile marine, say Lloyd's latest returns, is 21,542, with an aggregate tonnage of 12,203,761 tons. Of this number, 7,960 are steamers with 8,980,203 gross tons, or an average considerably over 1,000 tons each. Last year England added 872 vessels of 984,670 tons, of which 21,000 tons were purchased from foreigners. But England also sold to foreign nations, chiefly Norway, France and Germany, 117,000 tons more than she purchased. In the last six years nearly 4,500,000 tons of steamers have been added to the register, and only 1,600,000 tons have been removed ; and of the latter the greatest number have only changed flags, and are still competitors for trade. In the same period 913,000 tons of sailing ships have been added on 1,206,000 tons removed ; so that there are fewer sailing ships on the register now than in 1887.

An Amphibious Boat.—A new Canadian invention for use in the lumber districts is coming into general use in Northern Ontario. It is called a steam-warping tug. It propels itself on land as well as on water, and is used by lumbermen whose operations are carried on among small lakes connected by streams of uncertain navigation. The vessel has proved not only a success, but a great boon to the lumber trade. Six of these unique crafts have been built by the inventors during the past season, four completed at their yard and two shipped ready to be put together at their destination in the Nipissing district. They are built in scow shape, with steel-shod runners for moving overland ; are 37 ft. long, 10 ft. beam, decked all over, and have sleeping room for four men in the bow ; the bottom and up the bow is covered with steel boiler plate. An engine of 22 H.P. furnishes steam for 10 hours' work, with three-quarters of a cord of dry wood. In the water it moves six miles an hour forward or backward, as required, propelled by sidewheels. On land it is propelled by having a cable drum, on which is coiled five-eighths of a mile of steel wire cable, which is fastened with pulleys to a tree or some object in front, the boat moving as the wire is coiled up. The boiler is hung on an axle in the center, and a screw arranged on the front enables the fireman to tip it forward or back and keep it level going up or down hill. It will move over an elevation of 1 ft. in 3 on land, and draws about 28 in. in the water.

The "Bannockburn."—The *Bannockburn* is the name which will be given the new steel screw steamer recently constructed in the dockyards of Sir Raylton Dixon, Middlesborough, England, for the Montreal Transportation Company. The length of the vessel over all is 253 ft.; breadth, 40 ft.; molded depth, 21 ft. 3¾ in.; depth of hold, 18 ft. 7¾ in. Her dimensions are thus exactly adapted to the capacity of the Welland Canal. Although specially adapted for carrying freight, she will have first-class accommodation for a limited number of passengers. The saloon is situated in the after part of the vessel and will be handsomely furnished. The engines of the *Bannockburn* will be triple-expansion, having three cylinders of 21 in., 34 in., and 56 in. diameter, and a stroke of 39 in. She will have two boilers, each 39 ft. 9 in. long by 9 ft. 9 in. in diameter, tested to a working pressure of 160 lbs. to the square inch. The steamer will have five water-tight compartments, and provision is being made for ample water ballast tanks being fitted in the bottom, capable of carrying 750 gross tons of water. By this means the hull will be caused to sit deep enough when entirely light to be easily handled. She will be lighted by electricity and a good deal of the work aboard will be done by steam. The vessel is fitted with a steam steering apparatus. The *Bannockburn* arrived in Montreal about June 1. She will be taken apart and floated up the St. Lawrence to Kingston in sections. This vessel will be indeed an important addition to the large fleet of Upper Lake vessels and a credit to the enterprise of the company which she belongs.

The Simplex and the Huge Torpedo.—H. C. Vogt, Copenhagen, describes in *The Steamship* the Simplex and the Huge torpedo. Each of these is designed to carry a crew within a short distance of the object aimed at. The Simplex torpedo carries a single man who drops into the water in a particular dress or swimming apparatus, about 500 ft. from the ship to be destroyed. While in the torpedo, he occupies a hollow breakwater, strong enough to protect him from small shot. In outward appearance the Simplex torpedo resembles the Whitehead, and it is so small as compared with an ordinary torpedo boat that it is much harder to hit and much easier to manœuvre. It is intended to use petroleum for fuel and to bottle up the steam so that the man aboard can devote his entire attention to the helm and manœuvres. The Simplex was submitted to the United States Navy Department, which objected to it because of its dependence upon the boiler and machinery which must be left unattended during the time occupied in approaching the enemy, which may be for hours, and was then expected to develop its greatest power at the moment of attack. It was urged, too, that the change in trim at the critical moment of active service would cause a serious deflection in the course of the torpedo, and that the design was not sufficiently developed and reliable. In the Huge torpedo, the powerful spring releases a small boat about 600 ft. from the object of attack. This boat is protected by a small shield on the torpedo, and when launched is propelled by means of oars or by a screw with machinery similar to that of the Whitehead torpedo. It is expected to attain a speed of 1,700 ft. in a minute, and is exploded on impact by the crushing in of the bow and the ignition of kalium by the inrushing water.

Heavy Coal Consumption not Unprofitable.—The *Saturday Review* says that when a man talks of a fast boat, a 22-knot boat, which means a 25-mile boat from Queenstown to Sandy Hook, the pessimist utters the word "Coal!" and feels that no more terrible condemnation could be uttered. The coal consumption of the *Campania* is, no doubt, great ; it has to feed 30,000 horses at full gallop for 2,800 knots ; and the gallop will last about five days and a quarter ; but, although this means over 2,500 tons of coal for the trip, the shorter trip means less human fuel in the shape of fewer meals for the passengers. The quick passage is all in favor of the ship-owner in the commissariat of the ship. Many of the passengers become hungry only on the fourth day, and the reduction of the journey from 10 to five days means something considerable in the consumption of beef, seeing that the reduction is always in the hungry days. The ship-owner calculates, with appalling indifference to suffering humanity, that if the passage could be shortened a day or two more, some of his pas-

sengers could be landed just at the time they were beginning to think about the cook as a person of consequence. There is another practical view of the case. A ship that can make a voyage to New York and back in a fortnight will earn 52 freights in the year, instead of the 26 of the boats of 20 years ago. The crew costs no more, if the coal does, and the earnings are double. But there is yet another view of the matter. The late Sir William Pearce, who began these fast boats by the building of the *Arizona*, and whose successors at Fairfield have built the *Campania*, once asked a friend, whose imagination reeled at the idea of a 22-knot boat, whether he would not prefer to go down in a fast boat in preference to meeting an ignominious death in an ocean tramp. The humor of the sentiment lies in the fact that it is the ocean tramp that always goes down in the case of a collision; and it is the fast boat that sends the tramp down. Parliamentary humanitarians should see to this. Surely their reckless ingenuity is equal to the discovery of some way of preventing people from choosing their mode of drowning.

Steel Chords Broken.—The loss of the steamer *Western Reserve* on Lake Superior last season demonstrated the extent of the punishment that can be inflicted upon huge steel steamers by running them full tilt against heavy seas, and served the purpose of recommending wooden vessels to public favor, because of the impossibility of breaking them in two through similar usage. Nevertheless large wooden steamers suffer heavy punishment and are often brought to what might be styled the breaking point while being forced against head seas in light trim. This has been clearly demonstrated in the case of two of the largest wooden steamers of the Milwaukee fleet. One of these is the *Ferdinand Schlesinger*, which came out in 1891. She has a net measurement of 2,087 tons, and next to the *William H. Wolf* is one of the strongest boats of her class turned out from the old Wolf & Davidson yard. In addition to an abundance of diagonal strapping, two steel chords 18 in. wide and $\frac{5}{8}$ in. thick, placed on the inside and outside of the heads of the frames and fastened together with through bolts, traverse the full length of the craft. During the two seasons she has been in commission the *Schlesinger* was on several occasions driven in the face of storms without cargo, and now it is discovered that on the port side, at a point about 50 ft. forward of the boilers, both of these heavy top chords have been fractured. The broken plates will be secured with laps. The second instance is presented by the steamer *Helena*, though not in so marked a degree. The *Helena* had an outer chord of steel 10 in. wide and $\frac{1}{2}$ in. thick traversing the heads of her frames. On being stripped at the south yard, the other day, two laps of this chord, at a point about amidship on the port side, were found to have suffered a clean fracture. The chord has been removed, and hereafter the *Helena* will carry an inside and outside upper chord of steel 24 in. wide and $\frac{3}{4}$ in. thick. Here are two marked cases of severe punishment to wooden steamers that have come to light because their owners have made no secret of the matter. There can be no question that numerous similar cases exist at other points along the lakes, and that the facts are kept carefully concealed from the public.—*The Evening Wisconsin.*

Visibility of Colored Lights.—The Lighthouse Board have recently been making some investigations regarding the intensity of lights used by the merchant marine as anchor and running lights. The method by which the observations were made were that three lights—a red, green and white—were located on the shore 25 ft. apart and about 15 ft. above water. Buoys were then placed at distances of 1, 2, 3, 4 and 5 miles from the shore station, ranged with the lights. A signal code was arranged by which the vessel from which the observations were made could signal as to whether the intensity of the light was to be increased or diminished. The experiments were begun about 8.45 in the evening. It appears from them that at 1 mile a white light of 1 candle power is clearly visible, while for red and green lights 3.2 candle power is fairly visible; at 2 miles' distance a white light of 3 candle power is clearly visible, and red and green lights of 29 and $28\frac{1}{2}$ respectively clearly visible; at 3, 4 and 5 miles white lights of 3, 23 and 33 candle power are clearly visible.

The second series of experiments were made two weeks later, in which the committee attempted to determine the least candle power at which lights of different colors could be definitely seen at various distances, and it was found that this was not capable of a rigorous solution. In the first place, the eyesight of different observers varies, and a light of a certain candle power would be clearly visible to one while indistinct to another, and might be invisible to a third. Again, on different nights, apparently clear, the nature of the atmosphere, dry or humid, dusty or clean, would have a considerable influence on the range of the visibility of the lights. In cases of colored lights, red or green, the amount of absorption would increase with the density of the color of the glass, and this would also cause large variations in the range of visibility with lights of the same candle power behind it.

All of the above was taken into consideration by the committee in drawing its conclusion, and although the candle powers recommended are not the least that can possibly be seen in all cases, yet they are believed to be the least which can be used and still give a proper margin of safety. From the table which was prepared it is seen that for a white light the candle power recommended is 1, 2 and 30 for distances of 1, 2 and 5 miles respectively; for red and green lights the candle power is 4 and 40 for 1 and 2 miles respectively.

The "Bonaventure," shown herewith (figs. 1 and 2), is a cruiser of a new type, lately launched from the dockyard at Devonport. She is built of steel, with bronze stem and stern posts, and the hull is wood-sheathed with $3\frac{1}{2}$-in. teak and covered with copper. The length of the ship between perpendiculars is 320 ft.; breadth, 49 ft. 6 in.; and the normal displacement, with all her weight on board, will be 4,360 tons on a mean draft of water of 19 ft. Unlike the smaller cruisers recently constructed, the *Bonaventure* has a flush deck fore and aft, instead of a poop, forecastle, and waist. A distinctive feature of this cruiser is her steel protective deck extending right fore and aft, the forward part running down with a long sweep to the ram, of which it in reality forms a part. This

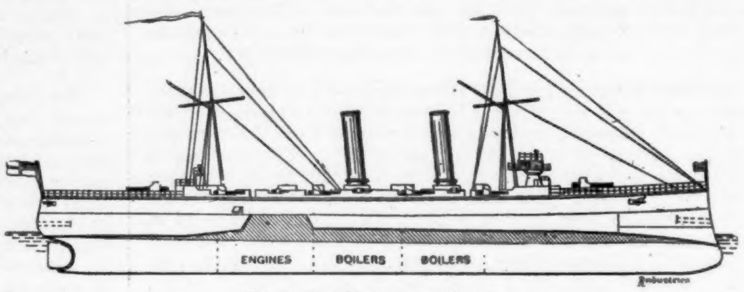
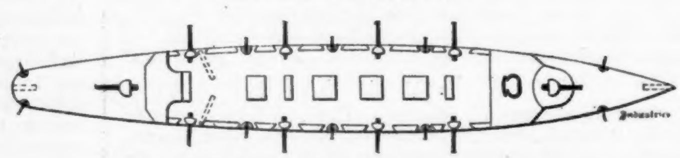


FIG. 1.—SIDE ELEVATION OF VESSEL



NEW ENGLISH CRUISER "BONAVENTURE."

deck is arched transversely, so that at the sides of the vessel it is about 4 ft. below the normal load-water line, while at the centre of the ship it rises to a height of about 1 ft. above the water. It is composed of two layers of plating, measuring together 2 in. in thickness in the sloping parts amidships, and 1 in. in thickness on the flat part. Beneath this deck are situated the various magazines, and the propelling machinery and boilers. The propelling machinery consists of two sets of vertical triple-expansion engines to operate twin screws; they are capable of developing collectively upward of 9,000 H.P. under forced draft, the resulting speed being estimated at 19.5 knots. Owing to the adoption of the vertical type of engine, the tops of the cylinders project above the level of the protective steel deck, and, in consequence, it has been found necessary to form an armored breastwork around the cylinders, the sides of which are built up of compound-steel armor plates, 5 in. thick, supported by steel Z-section bars. A double bottom extends throughout the engine, boiler, and forward magazine spaces, and in order to localize any damage which may occur to the hull, the vessel is divided into about 80 water-tight compartments, of which the hold proper contains 55. The heaviest guns carried will be two 6-in. quick-firing weapons, one mounted forward firing in a direct line ahead, and the other mounted aft with direct fire astern. In addition, there will be eight 4.7-in. quick-firing 36-pdr. guns, mounted four on each broadside. These guns are capable of firing about 12 shots per minute, and have a penetrative power equal to about 8 in. of iron. The auxiliary armament—if it may be so termed—will comprise ten quick-firing 6-pdr. Hotchkiss guns, and

four machine guns. There are also four torpedo-tubes, one fixed at the bow, another at the stern, and two others capable of being trained through a very large arc, situated one on either broadside.—*Industries*.

PROCEEDINGS OF SOCIETIES.

Association of Foremen Blacksmiths.—A call has been issued to the foremen blacksmiths of the United States for a meeting, which is to be held at Chicago on September 5, at 10 o'clock in the morning, at 109 of the Rookery Building, for the purpose of establishing a national organization for mutual benefit. Representatives from the mechanical press and iron and steel houses who may be interested in the matter are cordially invited to attend. The committee are: J. J. Thornton, C. H. Williams, W. J. Lottes and George F. Hinkens.

Engineering Society of Western Pennsylvania.—At a recent meeting Mr. E. D. Estrada presented a paper giving a complete account and analysis of experiments which he had made on the effect of suddenly applied loads upon the tensile strength and other physical properties of wrought iron and steel. The experiments described went to show that by a suddenly applied load elongation of these materials is very materially increased, and this occurred throughout the entire lot without a single exception.

The questions considered in the analysis of results were, Why does the elongation increase when the loads are suddenly applied, and why is the elastic limit in a like manner diminished? Will the sudden application of load diminish the load of a bar of iron or steel from that which would be developed had the load been gradually applied? When the same kind of material is tested in the screw, it is found that, although the elongation increases as the time diminishes, the resistance remains the same; therefore it seems reasonable to conclude that the elongation is a time effect, and that for two identical test pieces the resistance which would have to be overcome in both cases before fracture could occur would be the same, irrespective of the conditions under which the loads were applied, while the effects produced may differ.

OBITUARY.

John Stephenson.

John Stephenson, the famous car-builder, died on July 31 at New Rochelle, N. Y., of old age. He was 84 years old, and had no particular ailment. Mr. Stephenson was born in County Armagh, Ireland, on July 4, 1809. The family settled in New York in 1811. After a course at the Wesleyan Seminary, this city, he was apprenticed to a coach-maker in Broome Street.

During the first two years of young Stephenson's apprenticeship to Andrew Wade, of 347 Broome Street, he spent his evenings drawing and designing. Abram Brower, a liveryman at 661 Broadway, the pioneer of the Broadway omnibus lines, had for four years run "accommodation vehicles" from the corner of Broadway and Bleecker Street to Wall Street, fare one shilling. His carriages were repaired at Andrew Wade's by young Stephenson.

In 1831, after his apprenticeship was completed, Mr. Brower invited Mr. Stephenson to open a shop at 667 Broadway. On May 1, 1831, Mr. Stephenson began business there on his own account. Then he designed the first vehicle known in New York as an "omnibus," which was quickly followed by the *Minerva*, the *Mentor*, the *Forget-me-not* and others. On the 29th of the following March his shop and all his stock were destroyed by fire. Then he started again at 264 Elizabeth Street.

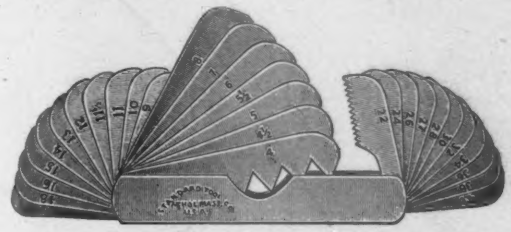
Mr. Stephenson had a growing omnibus trade, but the New York & Harlem Railroad, which was chartered on April 25, 1831, presented a new field for the exercise of his skill. This, the first of street railroads, confined by its charter to the corporate limits of the city, had for its president John Mason of the Chemical Bank. The business and passenger office was on the east side of the Bowery, two doors below Stanton Street. The company arranged with Mr. Stephenson to construct a car of entirely new design. The Stephenson car, *John Mason*, named after the president of the road, has become historical as the first street car ever used. On November 26, 1832, the road was opened from Prince Street to Fourteenth Street. On its first trip the car carried the Mayor and Common Council of the city. Mr. Stephenson received a patent on the car, now in possession of his family, signed by Andrew Jackson, President of the United States, and by members of his cabinet. Other orders from the same company followed, and in three years orders were received from Paterson, Brooklyn, Jamaica, N. Y., and from Cuba and Florida.

His business continued to extend, and his cars were sent to many foreign countries. The factory in East Twenty-seventh Street now employs 500 men. During the war he did good service, building many pontoons and gun carriages. Mr. Stephenson was regarded as a man of unflinching honesty, and at one time when he failed he refused to take advantage of the Bankruptcy Law, ultimately paying up every cent in full. About 27 years ago he made his home at "Clifford," New Rochelle. In 1833 he married Julia A. Tiemann. He leaves two sons and a daughter.

Manufactures.

NEW SCREW PITCH GAUGE.

We illustrate a new screw pitch gauge which is just being brought out by the Standard Tool Company, of Athol, Mass., for determining all pitches in common use from 4 to 40 per inch, including those for pipe and brass work from 11½ in. to 27 per inch. The leaves are made narrow enough so that they will readily enter the nut, and can then be used for internal work. There is also a stop which prevents the leaf from opening beyond a line straight with the handle, which further facilitates its use for inside work. The larger pitches are so arranged that they can be used as a gauge for grinding tools.



NEW SCREW PITCH GAUGE.

AN ELECTRIC HEATER.

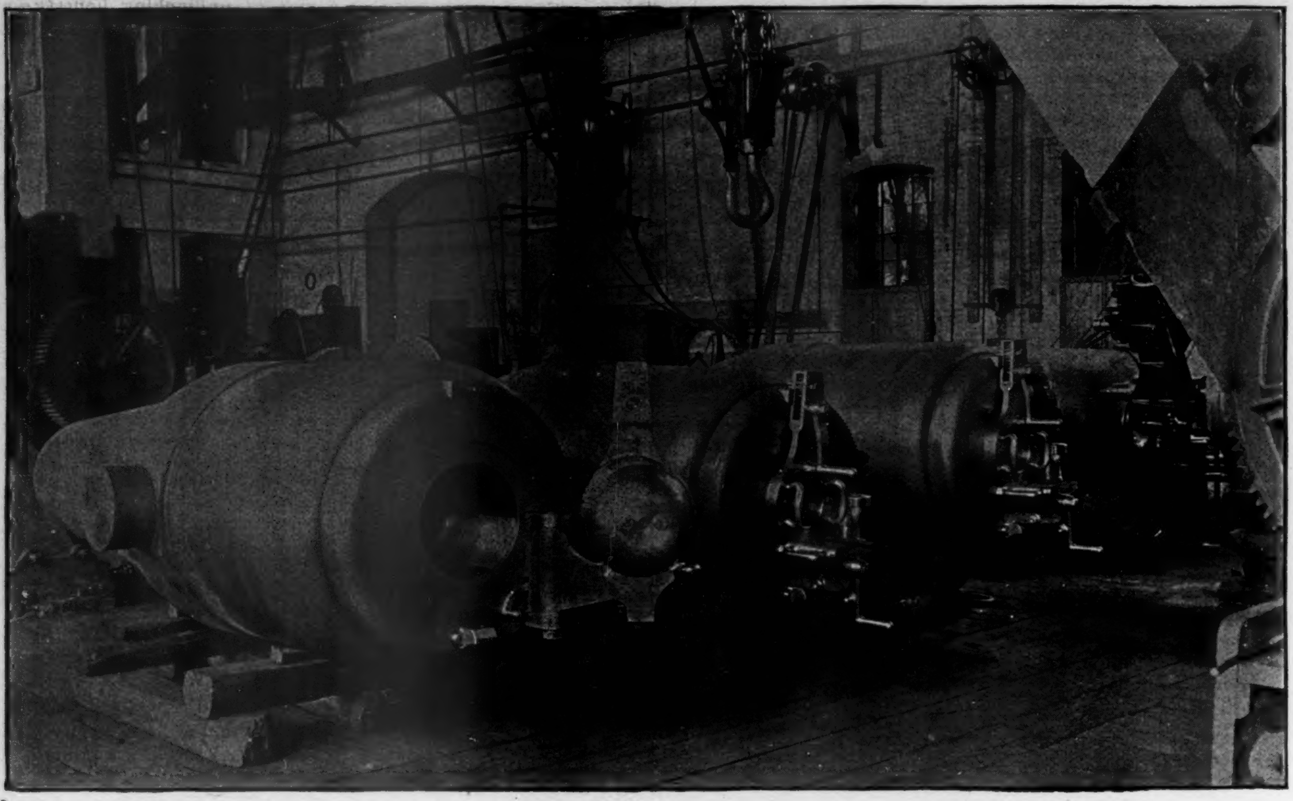
Messrs. Lagrange & Hoho, two Belgian scientists, are the inventors of a new method of heating, melting and refining metals by means of electrical heat. The apparatus consists of a glass or porcelain vase of any size conveniently adapted to the purpose, provided with a lining of lead connected with a strong conductor of positive electricity. This is filled to three-fourths its capacity with acidified water. A pair of iron tongs with insulated handles is attached by a flexible conductor to the negative pole of an electrical current generated by an ordinary dynamo. The electrical current having been switched on, a bar of wrought iron or other metal is taken up with the tongs and plunged into the water within the vase. The water immediately begins to boil at the point of contact; the immersed portion of the iron rises quickly to a red, then to a white heat, and emits a stream of brilliant white light. The heat becomes so intense that the iron melts and falls off in bubbles and sparks, leaving a clear, glowing surface in perfect condition for welding. The heating process has been so rapid that neither the water nor the end of the bar held within the tongs have been more than slightly warmed. If instead of a bar of metal a stick of carbon is used, the heat in a few minutes produces detached fragments of amorphous carbon, which proves scientifically that a temperature of 40,000° Celsius has been developed. During the recent experiments at Berlin the measuring instruments registered a tension of 120 volts and an energy of 220 ampères.

It is as yet too early to form any definite estimate of the practical range or commercial value of this discovery.

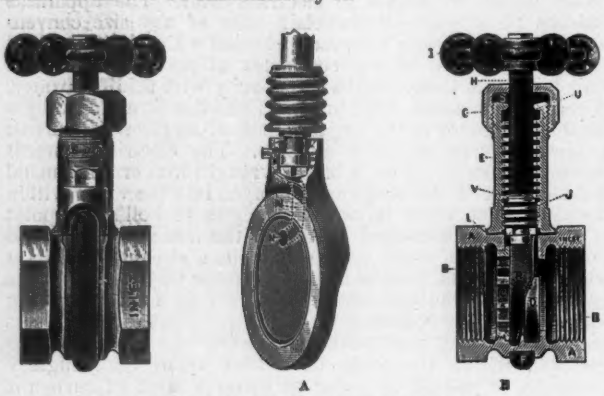
It has been applied to the welding of various metals with such success that it promises, in that special field, to inaugurate a complete revolution. The clean envelope of hydrogen which surrounds the heated metal prevents oxidation, and the welding surface is left free from the effects of sulphur and other impurities. It is believed that this may lead to important results in the hardening of and tempering of armor plates and other objects in iron and soft steel, in which great resistance to penetration or abrasion by friction is requisite, while preserving the interior tough and fibrous to resist concussion

or strain, as in many parts of machinery. At Essen Messrs. Krupp & Co. are experimenting with it in the hardening of steel cannon.

Whether it is applicable as an electrolytic process to the reduction of metals seems to be disputed. One account claims that by it the cost of refining gold, platinum, copper, nickel, and even iron will be reduced 80 per cent., while other authorities assert that, though metallic oxides may be successfully reduced by this method, no other foreign substances contained in the metal will be eliminated by it.



12-INCH BREECH LOADING RIFLE MORTARS, BUILT BY THE BUILDERS' IRON FOUNDRY.



THE "LUNKEN" GATE VALVE.

12-IN. BREECH-LOADING RIFLE MORTARS.

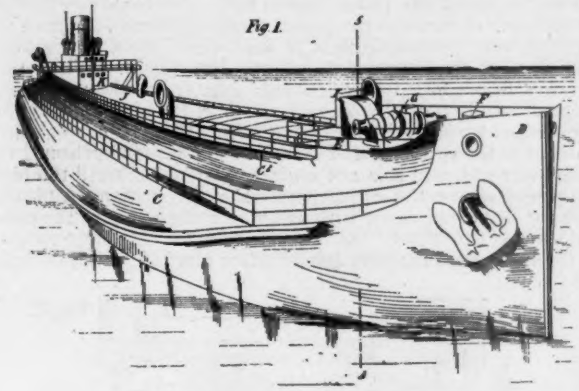
We present an engraving taken from a photograph of the 12-in. breech-loading rifle mortars built by the Builders' Iron Foundry, of Providence, R. I., and shown as they were laid out on the floor of the shop. These mortars are made with cast-iron bodies and two rows of steel hoops. The total length of the gun is 129.7 in., the diameter outside of the hoops being 42½ in. and weight 14½ gross tons, or 32,550 lbs. The guns are a part of the system of coast defense adopted by the United States Government in 1886, and 73 of them have been ordered at a cost of about $600,000. Their general appearance bears a close resemblance to the steel breech-loading rifles made by the Navy Department, with the exception of their length, which in the mortars is only 10 calibers instead of the 30 of the rifle.

The specifications call for the bodies to be made of charcoal iron, cast vertically breech downward and cooled by water circulation through the core on the Rodman process. Test specimens cut from both ends must have an elastic limit of 17,000 lbs. and a tensile strength of from 30,000 to 37,000 lbs. per square inch, or nearly double that of ordinary cast iron. The metal is melted in what is known as an air-furnace, and the iron, being separated from the fuel, is more uniform and homogeneous, and the results more reliable than can be obtained with the ordinary cupola. It takes about six hours to melt it, and then about two hours longer to bring it to a proper condition for pouring. The fuel consumed rises to about 37 per cent. of the weight of the metal. When the iron is tapped it flows through a long trough of fire clay directly from the furnace into the mould, and as soon as the piece is cast water is kept constantly circulating through the core and the cooling commences at once. The bore must be between 12 and 12.003 in. in diameter, and must be straight enough to allow a test cylinder 11.997 in. in diameter and 42 in. long to be slipped easily through its entire length. Sixty-eight grooves are cut in rifling, each 3.79 in. wide and .07 in. deep. These grooves have an increase pitch varying from one turn in 25 calibers to one in 40, the object being to avoid a too sudden initial rotation when the shot is fired. The steel projectile ordinarily used weighs 630 lbs. It is fired by a charge of 80 lbs. of brown prismatic powder, and at a distance of 6 miles will penetrate 4 in. of steel. It has a bursting charge of 30 lbs. of fine powder. As mounted, the gun can be fired about once in five minutes. It is proposed to distribute the mortars and mounts along the coast in groups of 16, and to have them shielded by earth embankments and fire them simultaneously by means of electricity.

THE "LUNKEN" GATE VALVE.

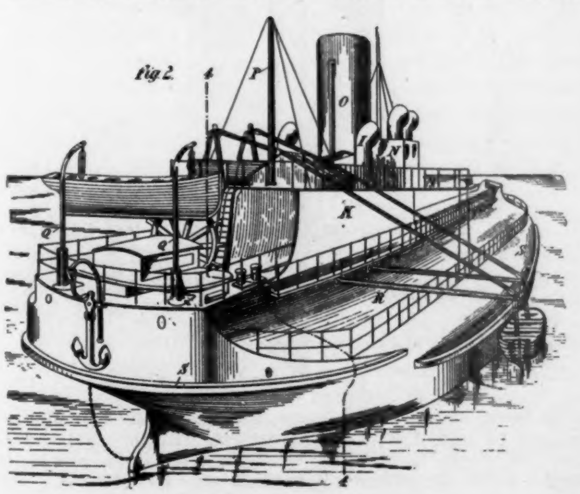
A new design of gate valve has recently been brought out by the Lunkenheimer Company, of Cincinnati, O., and we present illustrations of the same showing its general construction. The valve is available and intended for all pressures of steam or hydraulics which would be used or required in the workings of any plant.

The hub or bonnet is held to the shell by a coppered steel clip or strap surrounding the shell, with its end passing through the ears of the bonnet and secured by nuts *O*. This clip is held from lateral movement by projections on the shell. The joint is packed by a hard lead washer of $\frac{1}{16}$ in. thickness, the top faces of flanges each having a groove, to properly secure the washer. The valve can easily be taken apart without renewing the packing washer. The hub or bonnet is flat and narrow, and just of sufficient size to receive within it the valve disk when entirely raised, and has sectional or part-nut threads in its opposite interior sides. The threaded portion *J* of the stem by engaging with these part threads causes the valve to be opened or closed. The disk has a straight flat face or bearing against the renewable seat *C*, and is forced tightly against same by the self-adjusting wedging half-ring or horseshoe *D*, secured loosely in the valve shell. The wedging on the disk is applied on two wedging surfaces, diametrically opposite each other, these coming in contact with the beveled ends of the half-ring or horseshoe wedge; thus the wedging is properly equalized on the entire disk, and insures a tight joint on



DOXFORD'S CARGO STEAMER.—BOW.

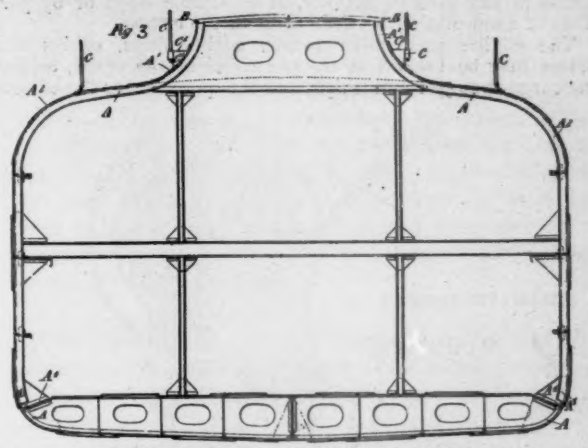
the opposite face. The pressure of the steam or liquid on the back or wedge side of disk also aids to make a tight closing valve. All valves above 2½ in. size are provided with "by-pass," which arrangement balances the disk before opening same, and thus reduces the friction and wear on seat and disk to a minimum, and makes the valve open easily, regardless of what heavy pressure may be on same. The "by-pass," as shown in plate A and briefly explained, is an auxiliary valve formed in the top of the valve disk (immediately below the yoke that secures the same to the flanged head of the stem *H*),



DOXFORD'S CARGO STEAMER.—STERN.

and is operated by the stem of valve, automatically, while opening or closing the main valve. Channel *N*, passing through the disk, connects the inlet or pressure side of the valve with the outlet side, and the end of the stem *H* controls this channel, there being sufficient play in the disk coupling to allow the complete opening of channel *N*, caused by the first ¼ turn of the wheel in opening the valve. Plate E gives a sectional view of the main valve.

The renewable seat, it will be seen by referring to the cuts, is an exteriorly threaded flanged ring that screws against a face or shoulder of the flange, the opposite side of which flange forms the seat or bearing surface for the disk to close against. The inner periphery of the ring has lugs or teeth, *K*, for the engagement of the wrench, by which means the seat is operated, and either taken out or put in through the disk opening of the body without disturbing the pipe connections. In iron body valves the renewable seat *C* screws into a second brass ring permanently fastened in the iron shell, otherwise, owing to the rusting qualities of iron, the renewable seat might rust tight in the shell. The ring end *T* of wrench is used to hold and guide the removable seat into place, so as to properly start its threads into the threads in the shell.



DOXFORD'S CARGO STEAMER.—SECTION.

The valve is exhibited by the company at Chicago in Section 25, Column O, 24, together with a complete display of the specialties which they manufacture.

THE ARGENTINE GOVERNMENT VERSUS RAILWAYS.

A correspondent in Buenos Ayres sends us some clippings from papers in that country containing editorial complaints that the Government in that country had taken ground that no more iron railway ties or sleepers should be admitted free of duty under the clauses of the concessions providing for immunity from import duties. This, it is claimed, is a violation of good faith, which is due to a mischievous and erroneous assumption that a railway is a public enemy, or at least a dangerous servant. One of the principal papers opposes the consolidation of the great Southern and the Western railways, because it fears the results of licensing such a powerful monopoly.

The management of railroads in that country does not seem to be faultless. The same correspondent says of some American cars that the doors forming part of vestibule arrangements have been either torn or taken off. Sleeping-cars built by some of the best manufacturers in this country are run in a disreputable fashion—one towel for a whole car full of passengers, no soap, no drinking water, and parties are allowed to keep up card playing, smoking, etc., in main compartments till 2 and 3 A.M., with lights going full head.

Sleeping-cars are execrable under the best management, but must be very objectionable indeed in Argentina.

Recent Patents.

DOXFORD'S CARGO STEAMER.

Figs. 1, 2 and 3 show a form of construction of cargo steamers for which patent No. 485,462 was recently issued to C. D. Doxford, of Sunderland, England.

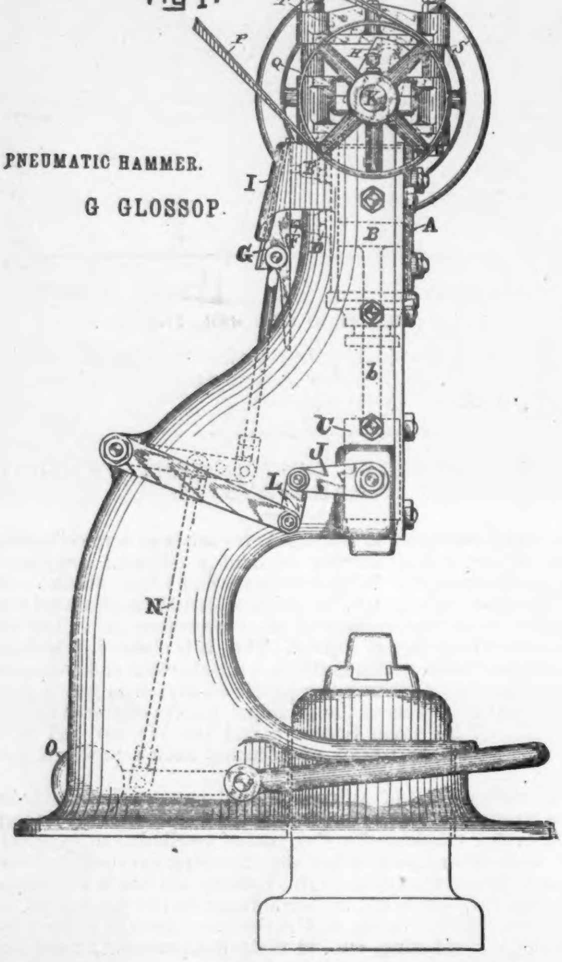
This invention relates to the construction and arrangement of the hulls of vessels, particularly steam vessels adapted for cargo purposes. These vessels could be used for various kinds of cargoes, but are particularly applicable to cargoes—such as grain, coal, oil and the like—which are more or less liable to shift and which are carried in bulk.

In carrying this invention into practice the ordinary deck is dispensed with and the sides curved inward with a convex curve for a suitable distance—say, for example, one third of

the total width at each side—and then upward with a concave curve, the top of these last curves reaching to the hatchway combings or the platform deck, in which the hatches would be formed. The above would represent the shape of the plates and framings amidships (the latter being carried continuously up as far as the plates) and these would be carried fore and aft without material variation for the greater part of the length of the vessel, merging at each end into a bow and stern of substantially ordinary construction. The hatchway extends over practically the whole length of the hold or cargo space, and may be closed by entirely independent covers, or these may be hinged or otherwise suitably connected and provided with permanent fastenings or arranged to be bolted down after each removal. The sides of the hatchway may be stayed across in any suitable manner, as by simple stays or by portions of fixed plating between some of the covers.

The engine and boiler rooms, coal-bunkers, cabins and offices may be located at the stern end of the vessel, behind the cargo-space, or amidships, and the quarters for the officers

Fig 1.



PNEUMATIC HAMMER.
G GLOSSOP

and crew either at the bow or stern, according to circumstances. The bows need not be carried up much higher than the before-mentioned hatchway combings or platform deck and would be left for the most part clear of incumbrances beyond possibly the warping-capstan, the windlass and the entrance to the forecastle or men's quarters, to protect which and generally to raise the height of the bows the forward plates may be carried up to a suitable level.

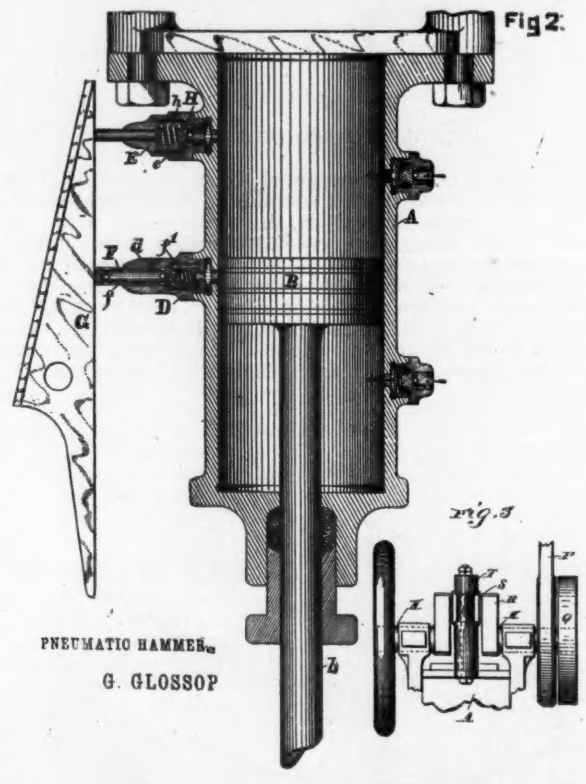
In the accompanying drawings, fig. 1 is a perspective view of a vessel constructed according to this invention taken from in front of the starboard bow. Fig. 2 is a similar view taken from the stern, and fig. 3 is a vertical midships cross-section showing the arrangement of the frames and plates.

GLOSSOP'S PNEUMATIC HAMMER.

The drawings given herewith show a power hammer for which patent No. 485,498 was recently issued to Gilbert Glossop, of Sheffield, England. It is of the class generally known as pneumatic hammers. Fig. 1 is a side elevation of a complete hammer; fig. 2 is a central vertical section through the cylinder, showing the valves and movable pressure piece; and fig. 3 is a detail view of the mechanism for reciprocating the cylinder, taken at right angles to fig. 1.

The drawings show generally the construction of the hammer, and are, perhaps, best explained by the inventor's own account of the operation of the device, which is as follows: "When the outlet-valve H is held closed and the outlet-valve F is opened wide, no air can escape from the cylinder except through the middle port. When the upper end of the cylinder and the piston are moving toward each other, all the air between the valve F and the upper end of the cylinder is imprisoned, and when this air is sufficiently compressed the downward movement of the cylinder is transmitted to the piston and it is moved downward; and under this condition of affairs it is moved downward farther and with greater force than when there is a smaller quantity of air imprisoned between the piston and upper end of the cylinder. Another reason exists why the piston moves downward farthest and with greatest force when the valves are in the described condition—viz., only so much air as is between the valve F and the lower end of the cylinder is imprisoned between said lower end and the piston when the piston passes said valve in its downward movement. Therefore the piston meets with less resistance to its downward movement than it does where there is a greater quantity of air imprisoned in said lower end. When the valve H is permitted to open with greater freedom and the valve F is only partially opened, much of the air in the cylinder escapes through the upper port when the piston is moving upward in the cylinder, and therefore less air is imprisoned in said upper end, and it is not entirely imprisoned until the piston passes above the upper port. For this reason the piston will not be moved down with as much force as under the conditions first explained. At the same time the air cannot escape so freely through the port E, wherefore more air is imprisoned

Fig 2.



PNEUMATIC HAMMER.
G. GLOSSOP

in the lower end of the cylinder, and this offers a greater resistance to said downward movement. In the first case a heavy blow may be delivered by the hammer-head close to the anvil. In the latter case a light blow may be delivered a considerable distance above the anvil. The force of the blow and the point at which it is most effectively delivered may be varied to almost any degree between the two extremes above described by varying the relative openings of the two valves through the movement of the wedge-shaped pressure-block G. In small hammers, when a very considerable variation in the force of the blow is not required, the upper valve may be omitted altogether, leaving simply an open port, and the variation in the blow would then result wholly from the difference produced by the operation of the middle valve in the air cushion below the piston, which resists its downward movement."